Temporary Non-Vegetative Soil Stabilization Evaluation Study for 2000 - 2001 Season

Orange County, California
CTSW-RT-01-066

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1.0 INTRODUCTION

California Department of Transportation (Caltrans) historically has employed many soil stabilization measures along California roadways. Caltrans has performed laboratory and field studies to evaluate the effectiveness of these measures to control erosion on cut and fill slopes; however, limited information exists as to their effects on storm water quality. Caltrans has begun to explore these effects by performing erosion control studies that emphasize and evaluate storm water related issues. One such study is the Temporary Non-Vegetative Soil Stabilization Evaluation Study. The initial plan of this study is to test several temporary non-vegetative soil erosion products in the field and over multiple years. Its general purpose is to assess the potential impacts these products may have on storm water runoff quality and their performance on reducing soil erosion.

This report presents the results for the first year of the Temporary Non-Vegetative Soil Stabilization Evaluation Study. It summarizes the scope, testing methods, and findings for seven temporary erosion control products tested at two field sites in Orange County, California. Results herein are for a portion of the 2000-2001 wet season (from approximately February through April, 2001), which is referred to here in as the 2000-2001 study season. The procedures used to select the sites and erosion control products, implement field testing of erosion control products, and monitor their performance were conducted in general accordance with the Caltrans Guidance Manual: Storm Water Monitoring Protocols 2nd Edition (Revised July 2000), and the Detailed Study Plan and Experimental Design dated March 2001 (the Study Plan [CTSW-RT-01-014]) and the Sampling and Analysis Plan dated March 2001 (SAP [CTSW-RT-01-001]) for the Caltrans Temporary Non-Vegetative Soil Stabilization Evaluation Study.

1.2 SCOPE OF WORK

The key work activities conducted during the 2000-2001 study season were:

- Review previous erosion control studies completed by Caltrans.

- Prepare a Study Plan and SAP.

- Evaluate and select sites for field-testing.

- Evaluate and select erosion control products to apply to selected sites.
- Design and construct test plots at each field site and apply the selected erosion control products according to manufacturer's specifications.
- Install storm water monitoring equipment at each site.
- Collect storm water runoff samples and monitor erosion from test plots during storm events.
- Evaluate the effects the products may have on water quality and their performance for controlling erosion.
- Prepare a Final report.

2.0 PREVIOUS STUDIES

Previous erosion control studies performed by Caltrans were reviewed as part of the planning and project design process for the temporary non-vegetative soil stabilization measures study. In general, these reports summarize the results of various erosion control products that were applied with the objective of reducing sedimentation and enhancing establishment of vegetation. The reports also include descriptions of the methodologies that were developed for establishing field and laboratory tests and design of small-scale soil erosion study plots. These studies are summarized below:

District 7 Erosion Control Pilot Study, Detailed Study Plan and Experimental Design, Woodward Clyde, May 15, 1998. The objective of this study was to evaluate alternative soil stabilization methods designed to minimize the transport of sediment from cut and fill slopes within Caltrans District 7 right-of-ways. The report summarizes the initial steps of an erosion control study focusing on reducing the quantity of sediment discharged to storm water drainage systems. The report describes erosion control problems within Caltrans District 7 and includes a review of previous erosion related studies and field observation of District 7 sites with erosion problems. The results of the review indicated that although a wide variety of erosion control materials were in use, evaluation of the effectiveness of these measures was not being adequately addressed. The current erosion control practices of Caltrans and other state and federal agencies were also evaluated. These practices include the use of various types of natural fibers and mulches, with the major emphasis on vegetative solutions for erosion control. Field and laboratory studies performed by entities other than Caltrans were also reviewed. This review indicated that much of the available data was not directly relevant because vegetation types or site parameters in the studied sites were not typical for District 7 sites. Areas where there was insufficient data available for erosion control decision making were identified. These included the long-term effectiveness of control measures, native plant establishment techniques, and measurement of erosion rates. Vegetative erosion control candidates were selected for testing and an experimental design and monitoring methodology was established.

Caltrans Roadside Erosion Control Effectiveness Storm Water Monitoring Study, 1997-2000 Summary Report, Districts 7 and 11, August 2000. The purpose of this study was to evaluate the effectiveness of erosion control measures at three sites, two in District 7 and one in District 11, that implemented Caltrans erosion control BMPs. Storm water quality monitoring of inorganic constituents was performed before and after the erosion control measures were implemented. Storm water samples were collected at the sites during a baseline period (1997-1998) prior to the installation of erosion control BMPs and also following implementation of erosion control BMPs (1998-2000). Rainfall for the various monitoring events was also measured. The analytical results of storm water monitoring prior to and following implementation of BMPs were statistically analyzed and compared. Test results indicated limited success at reducing inorganic constituents in runoff from the sites. The study concluded that BMP performance was likely influenced by site-specific installation and maintenance procedures.

Soil Stabilization for Temporary Slopes, URS Greiner Woodward Clyde, November 30, 1999. This document was prepared as a field guide for Caltrans personnel to assist with selecting erosion control products for ongoing construction activities and for final stabilization of disturbed areas. The guide is based on information developed as part of the District 7 Erosion Control Pilot Study (see below). The document includes tabulated data comparing various stabilization products and criteria for product selection. These tables include a qualitative indication of potential impacts to runoff water quality for the various products. The results of this study were used as a screening tool during the product selection phase for this study.

District 7 Erosion Control Pilot Study, June 30, 2000. This report summarizes the results of a study of soil stabilization methods designed to minimize the transport of sediment from cut and fill slopes within Caltrans District 7 right-of-ways. This study follows the pilot study design described above in URS Woodward Clyde, 1998. An evaluation of five surface roughening techniques was performed. The report concluded that several roughening techniques were effective at reducing erosion. The study also evaluated the effects of temporary irrigation on plant density and coverage. A positive short-term effect on seed germination was noted.

Fifteen soil stabilization measures were tested and ranked according to erosion rate and total coverage after two years. These rankings along with cost data were tabulated. The study concluded that many of the stabilization measures were effective at significantly reducing sediment in runoff. Water quality data from storm water runoff at the sites was statistically analyzed and evaluated. Certain wood or fiber based stabilization products were found to increase total organic carbon (TOC), biological oxygen demand (BOD), and chemical oxygen demand (COD) in runoff. No specific ranking system for water quality effects was established.

3.0 PROJECT OVERVIEW

The following subsections provide an overview of key elements of the 2000-2001 study season, including site selection process, erosion control product evaluation and selection, and design and construction of the test plots.

3.1 MONITORING SITE SELECTION

This section describes the criteria used to evaluate candidate sites for testing, the methods used to identify candidate sites, and the two sites selected and constructed for the Temporary Non-Vegetative Soil Stabilization Evaluation Study.

3.1.1 Criteria For Evaluating Candidate Sites

General criteria were developed to evaluate candidate sites. The eight criteria listed below are considered relevant for selecting sites for testing of temporary erosion control products.

1. Personal Safety

Safety at field sites during construction, monitoring, and sampling is a mandatory priority. As such, selected sites needed to adhere to all Caltrans safety requirements (e.g., distance from roadway). Other safety mandates adopted for this study included lane closures only during construction and no redirection of traffic flow during monitoring or sampling. Sampling equipment and work areas needed to be readily accessible to personnel without safety concerns.

2. Site Monitoring and Sampling Logistics

Sites must allow storm water runoff from test plots to be conveyed into existing drainage systems with only relatively minor modifications. Existing drainage systems also needed to accommodate storm water monitoring using automated monitoring equipment. Furthermore, selected sites must allow independent collection and sampling of runoff from individual test plots (i.e., not allow run-on from non-test areas).

3. Site Accessibility

Selected sites needed to be readily accessible to Project Team offices on a 24 hours a day, 7 days a week basis. This facilitated site inspections, monitoring, and sample collection and reduced travel times, costs, and sampling logistics. Potential sites in Districts 6 and 12 were evaluated because of their proximity to Project Team offices in Orange County and Fresno, California.

4. Site Conditions and Constraints

When possible, the study targeted sites recently constructed or regraded, or sites where vegetative erosion control measures had not been adequately established. Also, the Project Team targeted sites that have relatively uniform conditions within a given site, such as soil type and slope inclination and height. Constraints such as sensitive animal habitats, aesthetic issues, and other site-specific issues identified by Caltrans were key considerations.

5. Site Area

Individual test plots needed to be large enough to represent typical full-scale applications (such as road cuts and construction slopes and sites) and provide sufficient runoff quantity to measure runoff flow and collect storm water samples with automated samplers. The minimum flow rate accurately measured during the 2000-2001 study season was approximately 0.006 cubic feet per second, which was accomplished using a flow sensor in a 6-inch Palmer-Bowles flume. The minimum plot size to provide this minimum flow is approximately 0.1 acre (calculated using the Rational Method). This minimum size also could represent a full-scale application.

Sites were considered if they accommodated at least three adjacent test plots of at least 0.1 acre each. This allowed two or more products and an untreated bare soil plot (referred to herein as a control plot) to be tested concurrently. Testing more than one product at a single site helped to reduce variations inherent between sites, such as sunlight exposure, rain intensity, soil conditions, and others.

6. Equipment Security

When possible, sites were preferred that restricted or limited public access for security of equipment and safety.

7. Non-interference with Caltrans Activities

Sites were selected where testing of erosion control products would not interfere with current or anticipated future Caltrans construction projects or other activities.

8. Power and Cellular Phone Access (Preferred)
Access to power and cellular phone coverage at a candidate site was preferable, but not mandatory.

3.1.2 Methods to Identify Candidate Sites

Using the section criteria above, the Project Team identified potential sites in Districts 6 and 12. Districts 7 and 11 were also contacted regarding this study, but no candidate sites were evaluated in these districts during the 2000-2001 study season.

In District 12, the Project Team performed a reconnaissance along Routes 73, 241, and 261 to identify potential sites. Several sites along these routes were observed, photographed, and evaluated, including a site identified by District 12 at the Route 73/55 interchange. Aerial photographs, topographic maps, and/or as-built plans were also obtained from District 12, when available, to aid in identifying sites.

Two candidate sites in District 12 were identified that met the site selection criteria. These sites were reviewed and subsequently approved by District 12 and Caltrans Headquarters. They are described in the following section.

3.1.3 Description of Selected Test Sites

The two test sites approved by Caltrans are adjacent to Route 73 in District 12. The sites will be referred to hereafter as the 55S and 73S sites. The general locations of the sites are shown on Figures 1 and 2, respectively. A description of each site is provided below.

<u>55S Site</u>

The 55S site was the first site constructed for this study and is located at the Route 73/55 interchange in Costa Mesa, California. It is the site selected by District 12 and is an interior fill slope of the exit ramp loop connecting Route 73N with Route 55S. The fill slope has an average inclination of approximately 2:1 (horizontal:vertical) and varies between approximately 20 and 30 feet in height.

The site has an existing rock trench along the toe of the slope, which conveys runoff from the slope to an inlet near the trench's northern end. During testing of storm events, runoff was discharged to this drainage system after it flowed through the conveyance system constructed for this study (see Section 3.0).

73S Site

The 73S site was the second site constructed for this study and is located along Route 73S between approximately Highway Station Numbers 968 to 974. The site is a south-facing fill slope with an average inclination of approximately 2:1 and has an existing unpaved road and concrete v-ditch at about mid-slope. The existing v-ditch collects runoff from the upper half of the slope and conveys it to a descending concrete v-ditch near the southern end of the test site. The descending v-ditch transports the runoff down to the toe of the slope. During testing of storm events, runoff was discharged to this drainage system after it flowed through the conveyance system constructed for this study (see Section 3.4).

Plots were constructed over the upper half of the fill slope, just above the existing v-ditch and unpaved road. Height of the slope within the plots ranged from approximately 40 to 60 feet.

3.2 EVALUATION AND SELECTION OF PRODUCTS

The Study Plan provided a summary of non-vegetative erosion control products potentially suitable for inclusion in the Temporary Non-Vegetative Soil Stabilization Study. A description of criteria used to select the products is described below.

3.2.1 Selection Criteria

Product selection was based on the following:

1. **Impact on Storm Water Quality**
   Erosion control products that may have the potential to adversely impact storm water quality (based on previous Caltrans studies and product types) were selected for testing.

2. **Effectiveness of Erosion Control**
   Products that are potentially effective in controlling soil erosion when used according to the manufacturer's recommendations were selected for testing based on manufacturer claims and previous studies of similar products.

3. **Installation Costs**
   The cost to install products identified for possible inclusion in this study ranged from approximately $450 to $65,000 per acre; however, temporary soil stabilization products selected for testing during the 2000-2001 study season ranged from about $450 to $1,100 per acre. The lower range of costs reflects temporary and cost effective short term solutions for slope stabilization projects.

4. **Ease of Application and Cleanup**
The products selected for potential use during this study are relatively easy to install and cleanup of installation equipment is generally accomplished by rinsing/washing spray equipment with water.

5. **Availability**
The products are readily available for delivery to a site. Lead time generally ranges from several days to approximately two weeks.

6. **Currently Used by Caltrans**
Products that are currently used or are anticipated to be used by Caltrans were selected.

7. **Use as Non-Vegetative Measure**
Products that can be used as non-vegetative erosion control measures by Caltrans were selected.

3.2.2 Selected Products

Based on evaluation of available temporary soil stabilization products, a total of seven products that generally conformed with the selection criteria noted above were recommended to Caltrans for evaluation. Caltrans subsequently approved these products for testing during the 2000-2001 study season. Two products were selected for the 55S site: referred to hereon as Product A and Product B. Five products were selected for the 73S site: referred hereon as Products C through G.

Specific information regarding the manufacturer information and application for each product is summarized in Table 1. A brief description and general use of each product as a soil stabilizer is presented below.

3.2.2.1 Product A

Primary constituents in Product A include polyacrylamide, ammonium polyacrylate, a water-in-oil emulsion, and mulch. Product A has a high molecular weight and specific charge density, which enhances soil particle aggregation. According to the manufacturer, the product is appropriate for temporary erosion control lasting up to one season. The actual length of the product effectiveness is dependent upon a number of factors including climate, slope inclination, and soil/geologic conditions.

According to the manufacturer, Product A is effective for erosion control, slope stabilization, dust abatement, storm water runoff and silt control, and water quality control. Additionally, it can be effective for dust suppression along roadways, but is not intended for vehicular traffic.

3.2.2.2 Product B

Primary constituents in Product B include an acrylate/vinyl acetate polymer and emulsifying agents. Product B is used primarily for soil stabilization and as a dust control agent. This product is not generally used to support vehicular traffic.

3.2.2.3 Product C

Primary constituents in Product C include polyacrylamide and other acrylamide polymers. Product C is used as tackifier for binding mulch and seed in hydroseeding operations and can be used without mulch as a temporary soil erosion control measure.

3.2.2.4 Product D

Primary constituents in Product D include Plaster-of-Paris, gelatin, and cellulose fiber mulch. Product D is cementious plaster binder produced from high-purity gypsum and applied in conjunction with a mulch through a hydraulic process. The Product forms a uniform protective crust-like barrier that reduces water and wind induced erosion.

Product D is typically used for erosion control and as a cover for establishing vegetation on disturbed slope areas. The product is intended to be used during the initial establishment of vegetation.

3.2.2.5 Product E

Primary constituents in Product E include polyacrylamide and mulch. Product E is an anionic polyacrylamide that is typically used as a tackifier and binding agent. The product is typically mixed with a mulch and a hydroseed mixture and sprayed on the ground surface.

3.2.2.6 Product F

The primary constituent in Product F is polyacrylamide. Product F is a long-chain organic polymer developed to clarify drinking water. Product F has also been used for erosion control, enhanced infiltration and nutrient removal. If the treated area is disturbed by foot and/or vehicle traffic the product will not be effective and will need to be reapplied.

3.2.2.7 Product G

Primary constituents in Product G include guar gum, cellulose fiber and unspecified proprietary fillers. Product G is designed to be used as a daily cover material for landfills. The manufacturer indicated that the product has also been used as an effective erosion control measure. The manufacture reports that a single application of Product G has been effectively controlling erosion for approximately two seasons. Because it is a paper product, vehicular traffic should be avoided.

3.3 TEST PLOT DESIGN

Test plots were designed with the intent of measuring flow, and collecting and sampling storm water runoff from distinct and separate test plot drainage areas. Key components of the design were: 1) isolating plots so that runoff from each plot could be collected independently without influence from surrounding non-test areas; 2) calculating, using the Rational Method, a minimum plot size that provides an adequate quantity of runoff for typical storms in Orange County; and 3) designing an effective collection and measuring system for runoff from each plot. Each of these is discussed below.

3.3.1 Plot Borders

To monitor plots independently, bordering was installed around the limits of each plot. Considering the size of the plots (0.1 to 0.2 acres), slope gradients, and other site and study constraints, it was necessary to select a material that was inert and could be readily installed. Plastic paneling used for root control was selected that fulfilled the study requirements. The panels were approximately 18 inches high, interlocking, and relatively watertight at joints. They were buried mid-height in the soil as a protective barrier around the plots. In order to eliminate potential overspray of products into adjacent plots during application and mixing of runoff between plots during storm events, a gap of typically about 10 feet wide was used between borders of adjacent plots. Straw mats were placed on the bare soil in the gaps between plots for erosion control. Because of site constraints, a gap does not exist between the control plot and a test plot at the 55S site.

3.3.2 Plot Size

Plots needed to provide sufficient runoff from typical southern California storm events to allow flow measurements and sample collection using automated runoff monitoring equipment. They also needed to be sized so that they represented full-scale conditions. According to the manufacturers of the sampling equipment, flow rates of about 0.006 cubic feet per second (cfs) and higher can be accurately measured using the monitoring equipment selected for this study. Rainfall/runoff analyses were performed to estimate the minimum plot size needed to provide this flow rate during several storms in a typical year. These analyses are described below.

Historical rainfall intensity-duration-frequency (IDF) data were collected from the Orange County Hydrology Manual. The IDF data were not usable in their published form because the most frequent event listed is the 2-year storm, which has a probability of occurrence of only 50% during any year. However, sufficient data were available to calculate rainfall intensity for more frequent events and it was estimated that the 1.01-year (99% exceedance probability or 2.33 standard deviations below the mean) storm had an intensity of about 0.29 in/hr. This storm event was used in the analyses because of the probability that it would be met or exceeded several times in a year with average rainfall.

Runoff coefficients were estimated using the methodology described in Figure 819.2 (Runoff Coefficients for Undeveloped Areas) in Chapter 810 of the Caltrans Highway Design Manual, which accounts for slope, soil type, cover, and surface storage. Calculated runoff coefficients were reduced by about 20% because the data in Figure 819.2 are for the 5-year to 10-year storm. The runoff coefficient of each test plot after product application was assumed to be 0.2 in the analyses.

Results of the analyses indicate that a 1.01-year (99% exceedance probability) storm of 30 minutes duration will produce an average runoff flow rate of about 0.006 cfs from a 0.1 acre plot with a runoff coefficient of 0.2. This flow rate is sufficient for flow measurement using the automated monitoring equipment. These results suggest that in an average year there should be several storms that produce measurable runoff from a 0.1-acre test plot.

The limited area of the 55S site could accommodate only three 0.1-acre plots or two 0.15-acre plots. To allow at least two products to be tested at the 55S site, 0.1-acre plots were selected (two test plots and one control plot). Conversely, the 73S site did not have such area constraints. To account for uncertainties in runoff coefficients, weather, and other factors, the plots at the 73S site were increased to approximately 0.2 acre.

3.3.3 Runoff Collection and Sampling

As previously discussed, a requirement of this study was that runoff from each plot had to be collected, measured, and sampled independently from other plots. To this end, collection and monitoring facilities were designed for each plot that consisted of a concrete v-ditch, level concrete pad, 6-inch Palmer-Bowles flume, Sigma 900 Max automatic sampler, and a Sigma 950 flow meter.

The concrete v-ditches were constructed along the entire length of the bottom of each plot to collect storm water runoff. They were gently sloped to drain to one corner of the plots and housed the flume at their downstream end. Intake ports for the automatic samplers were installed in the bottom of the v-ditches upstream of the flume. The flume acts as a restriction in the v-ditch to produce a high velocity critical flow and a change in the level of the liquid flowing through the flume. The flow rate is determined by measuring the head on the flume at a single point using a bubbler sensor (bubbler). The flume type and dimensions were programmed into the flow meter to obtain the proper head-flow rate relationship for each of the monitoring installations.

Considering the size of the plots at the 55S and 73S sites, it was not economically feasible or logistically practical to collect all the storm water and sediment runoff from each plot during a storm event. A moderate storm event could produce thousands of gallons of runoff (not including sediment load) from one plot. As a result, a sampling program needed to be designed that collected samples representative of the runoff over small to large storm events. The Project Team selected the Sigma 900 Max automatic samplers because they: 1) can collect flow-weighted composite samples over an entire storm duration (can collect more aliquots during intense portions of storms); 2) are considerably less labor intensive then manually collecting periodic grab samples; 3) are approved and being used by Caltrans to collect storm water runoff for other Caltrans studies; 4) can collect storm information such as percent capture and hydrograph data; and 5) appeared to be the best available means to collect representative samples considering site and logistical constraints and other factors.

3.4 FIELD TEST IMPLEMENTATION

This section describes the methods used to construct and monitor the plots at the 55S and 73S sites.

3.4.1 Site Construction

Test areas were divided into two type plots, control and test. Control plots were untreated bare soil slopes that did not contain soil stabilizers and were monitored as a control. Test plots had a soil stabilizer applied to the slope.

Construction of the 55S site began on January 18, 2001 and was completed (without product applications) on January 28, 2001. The site configuration allowed three plots to be constructed. The three plots (12-201 through 12-203) are approximately 0.1 acre each, have similar dimensions, and encompass nearly the entire fill slope at the site. The plan view layout of plots at the 55S site are shown on Figure 3.

Construction of the 73S site began on February 5, 2001 and was completed (without product applications) on February 20, 2001. The five test plots (12-205 through 12-209) are approximately 0.2 acre each, have similar dimensions, and extend from the pre-existing unpaved road to the top of the slope. Control plot 12-204 was initially approximately 0.1 acre for the first two storm events (storm events February 25-26, 2001 and March 6, 2001) and extended upslope from the pre-existing road to approximately midway between the road and top of the slope. After the March 6, 2001 storm event, the size of control plot 12-204 was increased to 0.2 acre by extending the panel bordering to the top of the slope. At 0.2 acre, control plot 12-204 is longer and shorter than the five test plots at the 73S site. The plan view layout of the plots at the 73S site is shown on Figure 4.

Construction procedures for the plots at the 73S and 55S sites were similar and are discussed below. Photographs showing aspects of plot construction are shown on Figures 5 and 6 for the 55S and 73S sites, respectively.

Control plots and test plots were initially prepared by clearing and grubbing, grading, and roughening the slope by track walking. After track walking, the limits of the plots, v-ditches, and pads were laid out and staked. A backhoe excavated the trenches for the v-ditches and the level pads for the automatic samplers. Wood forms were installed in pad areas and along the trenches (where needed). Flumes were installed at the downstream end of the trenches. Concrete was then poured to create the equipment pads and v-ditches. Low retaining walls consisting of cinder block were constructed on the upslope side of the concrete pads. A buried sedimentation basin (approximately 4 feet by 4 feet by 4 feet deep) was also constructed of cinder block immediately downstream of the flume at control plot 12-204 (73S site).

Shallow trenches for the plastic panel bordering were hand excavated along the edges of the plots. The panels were installed in the shallow trenches and then the trenches were backfilled with excavated spoils and tamp compacted. Panels were typically buried approximately 9 inches below ground surface.

3.4.2 Product Application

The soil stabilization products were applied by the manufacturer or by a hydroseeding company selected by the manufacturer. An exception to this is Product F. The product supplier did not select an applicator for their product. Consequently, the Project Team selected a hydroseeding company to apply Product F. Application of the products is described in detail below.

3.4.2.1 55S Site

Product A and Product B were applied to test plots 12-202 and 12-203, respectively, at the 55S site. Photographs showing the product application process are present on Figures 7 and 8. Both products were applied on January 29, 2001 under damp climatic conditions. Precipitation occurred the night of January 28, 2001. The slopes were, however, relatively dry during application because they had been covered with plastic sheeting on January 28, 2001 before precipitation had occurred.

Product A was applied as a slurry mixture under pressure at a rate that ranged between about 6 to 7 gallons per acre of land. The product was mixed on site with a 1,500-gallon hydromulch machine equipped with continuous mechanical agitators to create a relatively homogenous slurry during application. The slurry mix ratio consisted of one gallon of Product A, approximately 227.5 pounds of mulch, and 300 gallons of water. The product was sprayed over the entire slope with a standard 2-inch fire hose from the slope crest down to the toe.

Product B was mixed by the manufacturer at their facility at a four-to-one water to product ratio, and transported the emulsion to the site in a 1,500-gallon hydromulch transport truck. The emulsion was applied by the manufacturer by spraying onto the slope under pressure at a rate of 670 gallons per acre (1 gallon per 65 square-feet) from the slope crest to the slope toe.

3.4.2.2 73S Site

Product C, Product D, Product E, Product F, and Product G were applied to test plots 12-205 through 12-209, respectively, at the 73S site. Photographs showing the product application process are shown on Figures 9 through 13.

Product D was mixed on site using a 1,500-gallon hydromulch machine equipped with mechanical agitators. The Product D mixture contained 1,000 pounds of the gypsum product, 300 pounds of mulch and 600 gallons of water. The slurry was continuously agitated during application to maintain a homogenous state. A 2-inch fire hose was used to pressure-spray the product slurry onto the slope from the slope toe to slope crest, at a rate of 5,000 pounds per acre of land. Dry and warm climatic conditions enabled the product to thoroughly dry and set.

Product E and Product F were the first two products applied at the 73S site. Both products were applied on February 21, 2001 under dry, cloudless and warm conditions. Product D was applied on February 22, 2001. Product G was applied on February 21 and 22, 2001 under similar dry and warm climatic conditions. Product C was initially applied on February 24, 2001 under wet conditions. It was reapplied to the slope on March 16, 2001.

Product E was mixed into a slurry on site using a 1,500-gallon hydromulch machine equipped with mechanical agitators, at a ratio of 5 pounds of product to 325 pounds of mulch and 600 gallons of water. The slurry was continuously agitated to maintain a relatively homogenous mixture during the application process. The slurry was sprayed over the slope surface with a 2-inch diameter fire hose at an application rate of 25 pounds of product per acre of land. The product was applied from the slope toe up to the crest. Climatic conditions were warm and dry after application, enabling the product mixture to thoroughly dry and set.

Product F was mixed on site inside a 500-gallon polymer tank. Five ounces of the product and 400 gallons of water were thoroughly mixed by jet agitation (re-circulated through a pump and the tank until thoroughly mixed). Continuous agitation was not required for the mixture to maintain its homogenous state during application. The mixture was applied from the slope toe to the slope crest.

Product G was also mixed with a 1,500-gallon hydromulch machine equipped with mechanical agitators. The mix ratio was 700 pounds of product to 1,000 gallons of water. The mixture was continuously agitated during application, and was sprayed onto the slope with a 2-inch fire hose at a rate of 3,500 pounds per acre of land. Because a limited supply of Product G was delivered to the site on February 21, 2001, the hydroseeder applied the mixture over a two-day period. On February 23, 2001 the product was applied to the upper third portion of the slope. The product application for the remainder of the slope was completed the following day. Dry weather allowed the product to set and dry.

Product C was the last to be applied at the 73S site. The product was applied to the entire slope on two separate occasions, February 24, 2001 and March 16, 2001. In both applications, the 16 pounds of product was mixed with 500 gallons of water in a hydromulch machine that was equipped with continuous mechanical agitators. The product was applied both times without mulch, which according to the manufacturer, is an acceptable application method. The mixture was sprayed from slope crest to toe at a rate of 80 pounds per acre of land. Precipitation within about two hours after the first application did not allow ample drying time, and prevented the Product from completely drying and adhering to the slope. Consequently, Product C was reapplied on March 16, 2001 under dry climatic conditions, allowing the product to thoroughly dry. However, during both applications, it was observed that a portion of the product did not adhere to the slope and ran off the plot.

3.4.3 Site Maintenance

Maintenance activities were conducted at the 55S and 73S sites following construction of the plots and application of the erosion control products. Activities included visual inspection of the plots and collection systems after each storm event, visual inspection of the automatic samplers prior to storm events, and repairs and maintenance of these facilities on an as needed basis. The v-ditches typically required only minor maintenance consisting of removing accumulated sediment and constructing weirs in the v-ditches for the control plots. The weirs were placed in the v-ditches to help control sediment and reduce clogging of the automatic samplers. The sedimentation basin for control plot 12-204 needed to be emptied of sediment and runoff after each storm event. The plots did not require maintenance, except for a shallow soil slump that formed at the northern border of plot 12-202 during a storm event. This required minor repair to the bordering panel and filling the cracks caused by the slope movement. Most of the maintenance involved the automatic samplers and related equipment, which is described in more detail below.

Operation and maintenance of the automated samplers at each site was conducted in accordance with the manufacturer’s specifications and Caltrans’ most current monitoring guidelines manual. Prior to each storm event, the sampling and flow measurement equipment was inspected in preparation of a pending storm event in accordance with a Pre-Storm Monitoring

Equipment Inspection Checklist. The primary maintenance activity related to the automated sampling equipment involved occasional problems with sediment load from control plots (or plots after the effective life of a product) during the larger rainfall events, which tended to clog the auto sampler and inhibit water sample collection. During storm events, v-ditches becoming filled with sediment were cleared by manually shoveling the sediment to the discharge end of the v-ditch on an as-needed basis. After and between storm events, the rain gauges and sampling equipment were inspected and cleaned to remove sediment and miscellaneous non-study related debris that accumulated during the previous storm. After cleaning, the rain gauges and sampling equipment were calibrated and their batteries were inspected to ready the equipment for the next storm event. In addition, storm information was retrieved from the data loggers on the automated sampling equipment and data loggers were reset for the next sampling event. This information was recorded on a Post-Storm Equipment Checklist.

3.4.4 Erosion Control Monitoring

Monitoring was performed at each test plot to evaluate the performance of erosion control products with regard to storm water runoff quality and to assess their effectiveness for controlling erosion during storm events. A description of the methods used to collect storm water runoff samples is provided in Section 4.0.

To assess the effectiveness of the products for erosion control, visual monitoring of the test plots was conducted during and after storm water sampling events. Visual evidence of erosion was recorded, such as rills and gullies, raveling, and sediment accumulation in v-ditches. Photographs of the plots were taken after storm events for comparison. Apparent weathering or degradation of the erosion control materials was also noted when observed.

4.0 DATA COLLECTION AND ANALYSIS

4.1 Sample Collection

During the 2000-2001 study season, storm water samples were collected from selected storm events and analyzed to provide data to assess the quality of storm water runoff from the control and test plots at the 55S and 73S sites. Flow-weighted composite samples, and in some cases grab samples, were collected during the 2000-2001 study season. Samples could not be collected from plots where a storm event did not provide a sufficient volume of storm water runoff for analysis. The storm events in which composite and/or grab samples were collected for each plot are summarized in Table 2.

In addition to storm water runoff samples, soil samples from the control plots and samples of each product applied were collected and submitted for laboratory analysis. The soil and product data were used to help assess the potential export of dissolved and suspended constituents into storm water runoff from the products and site soils.

The storm water sample preparation and collection procedures were conducted in general accordance with the Study Plan and SAP. A general summary of the general storm water sampling procedures including selection of the storm to be monitored, field measurements, and observations made during each storm monitoring event, and the methods used to collect, preserve, and handle storm water samples is provided in Appendix A.

4.2 ANALYTICAL CONSTITUENTS

Constituents selected for monitoring storm water runoff during the 2000-2001 study season included the minimum constituent list shown in Table 4.1 from the Caltrans Guidance Manual: Storm Water Monitoring Protocol, Second Edition, Revised July 2000. Additional constituents were added on a site-by-site basis using information from the MSDS sheets for the seven products. The additional constituents analyzed for the runoff samples from the 55S and 73S sites are provided in Table A-3 of the SAP. The constituents analyzed in the seven products and the soil samples collected from the two control plots are shown on Tables 5 and 4, respectively.

4.3 QUALITY ASSURANCE/QUALITY CONTROL

Quality assurance/quality control procedures were implemented in general accordance with the SAP, including using Caltrans Automated Data Validation (ADV) Version 1.1 software during the data validation process. A general summary of the laboratory analysis, field and laboratory quality assurance/quality control samples and procedures, data management and validation protocols, and data reporting conducted during this study are summarized in Appendix B.

5.0 FINDINGS

This section presents the findings of the temporary non-vegetative soil stabilization study for the 2000-2001 study season. The following sections present the rainfall data and characteristics for storm events monitored during this study, chemical results for soil samples from the control plots and product applied to the test plots, and a summary of specific data collected during each monitoring event including storm water quality runoff data and observations made to the erosion characteristics of each control and test plot.

5.1 STORM EVENT DATA

Precipitation during monitored storm events was characterized by total rainfall, duration of rainfall, and peak and effective average intensities. Peak average intensity (PAI) is defined herein as the maximum average intensity of a peak sub-event during a storm event. More specifically, PAI of a storm is obtained by identifying the peak sub-events of the storm and then calculating an average intensity for these sub-events by dividing the cumulative rainfall during each peak by its duration. The effective average intensity (EAI) of a storm event is calculated as the ratio of the sum of the cumulative rainfall for the sub-events identified and the sum of their duration. Total rainfall for each storm event is summarized in Table 3.

5.1.1 55S Site

From February 12 through April 30, 2001, a total of five storm events meeting Caltrans monitoring criteria occurred at the 55S site. These storms occurred on February 12, February 25-26 (referenced as the February 26 storm event), March 6, and April7. The February 12 and 26 storm events produced sufficient runoff to collect storm water samples from all the plots at the 55S site. The March 6 storm event produced sufficient runoff to collect a storm water sample from only one (12-202) of the three plots at the 55S site. The April 7 and April 21 storms did not produce sufficient runoff from the 55S plots to collect samples.

Total rainfall for the five events ranged from 0.16 to 1.83 inches with peak average rainfall intensities ranging from 0.28 to 0.56 inches per hour.

5.1.2 73S Site

Four storm events meeting Caltrans monitoring criteria (February 26, March 6, April 7, and April 21) occurred at the 73S study site. The February 26 and April 7 storm events produced sufficient runoff to collect storm water samples from all the plots at the 73S site. The March 6 storm event produced sufficient runoff to collect a storm water sample from only one (12-207) of the plots at the 73S site. The April 21 storm produced sufficient runoff to collect samples from all the 73S plots, except plot 12-209.

Total rainfall for the four events ranged from 0.28 to 2.45 inches with peak average rainfall intensities ranging from 0.16 to 1.08 inches per hour.

The largest rain event for both study sites occurred on February 26 and the storm with the greatest rainfall intensity occurred on April 21, 2001. Characteristics of the storm events (i.e., PAI and total rain) are shown on Figure 14. Figure 15 shows the correlation between EAI and PAI for the 2000-2001 study storm events.

5.2 SOIL SAMPLING RESULTS

Three soil samples were collected from the bare plots (12-201 and 12-204) and were submitted for laboratory analysis of metals. The soil sample results and calculated average metal concentration data for each site are summarized in Table 4.

5.3 PRODUCT SAMPLING RESULTS

Samples of the product applied to each of the test plots (12-202, 12-203, 12-205, 12-206, 12-207, 12-208, and 12-209) were submitted for laboratory analysis of metals and other inorganic and physical storm water runoff quality parameters. The results of the product analyses are presented in Table 5.

5.4 STORM WATER RUNOFF MONITORING RESULTS

This section presents the findings of field observations made related to erosion of plots and the results of storm water quality runoff samples collected during each monitoring event at the 55S and 73S sites.

5.4.1 55S Site

5.4.1.1 Visual Observations

At the 55S site, the control plot (12-201) provided the baseline for comparing the effectiveness of erosion control measures using Product A (12-202) and Product B (12-203). The following sections summarize the observations made during the course of storm events between February 10 and April 21, 2001 at this site. The occurrence and approximate percent cover of vegetation growth on the 55S site plots during 2000-2001 study storm season are summarized in Table 6.

<u>Control Plot (12-201)</u>

Figure 16 shows a time-series progression of control plot (12-201) over the 2000-2001 storm monitoring season. As shown on Figure 16, soil erosion was observed at the bare plot with the beginning of the first storm event on February 10, 2001. During this first storm event, rills formed throughout the control slope with the most significant erosion occurring in the northern portion of the plot. The erosion was evidenced by heavy loading of fine and coarser-grained sediment in the v-ditch at the toe of the plot, which required constant removal during intense portions of the storm. The heavy sediment load impeded the accuracy of measurements obtained from the flow monitoring equipment and clogged the intake of the automatic sampler during intense portion of the storm. The second storm on February 26 had similar intensity and caused continued heavy erosion of the control plot. Storm events on March 6, April 7, and April 21, 2001 contained considerably less rainfall and produced proportionally less erosion of the control plot.

As shown on Figure 16, sparse vegetation began to occupy the control plot by the March 6, 2001 storm monitoring event. The vegetation density continued to increase over the remaining 2000- 2001 storm monitoring season.

Product A (12-202)

Figure 17 shows a time-series progression of the Product A test plot over the 2000-2001 storm monitoring season. Based on field observations, there was little to no evidence of soil erosion from the Product A test plot (12-202) during the five storm events. Minor evidence of foaming was observed in the runoff discharged from the flume during the first storm event.

Following the March 6, 2001 storm event, a shallow slump was observed about two-thirds of the way up the slope near the northern portion of the test plot. The slump appeared to move down slope approximately one to two inches and created surrounding cracks up to two inches in width. Following the March 6, 2001 storm, the cracks were filled with soil and no further movement of the slope was observed during or after the April 7 and April 21, 2001 storm events. Of three test plots at the 55S site, the Product A test plot appeared to have the lowest sediment accumulation in the v-ditch and sampling equipment during the storm events.

As shown on Figure 17, sparse vegetation began to occupy the Product A plot by the February 26, 2001 storm event. The vegetation density continued to increase over the remaining 2000-2001 storm monitoring season.

Product B (12-203)

Figure 18 shows a time-series progression of the Product B test plot. During the storm events, minor soil erosion was observed and removal of sediment from the flume was occasionally required. Sediment loading impeded the accuracy of flow measurements and increased the number of sample aliquots collected during intense portions of the storm events on February

10, February 26, and April 7, 2001. Moderate evidence of foaming was observed in the runoff discharged from the flume during the February 10 and February 26, 2001 storm events.

Slight rill formation was observed near the northwest and southeast borders of the Product B test plot during the April 7, 2001 storm monitoring event. However, the product appeared to remain intact during the 2000-2001 storm monitoring season.

As shown on Figure 18, sparse vegetation began to occupy the Product B plot by the February 26, 2001 storm event. The vegetation density continued to increase over the remaining 2000-2001 storm monitoring season.

5.4.1.2 Storm Water Quality Results

As previously stated, storm water samples were collected during only three of the five qualifying storm monitoring events at the 55S site due. Two of the storm monitoring events did not produce sufficient storm water runoff to collect samples for analysis. A total of seven composite samples were collected from the 55S site during the 2000-2001 study season (see Table 2). The storm water quality runoff data for the 55S site are summarized on Table 7. A discussion of the storm water quality runoff results as they relate to the soil and product sample results is presented in Section 6.0.

5.4.2 73S Site

5.4.2.1 Visual Observations

At the 73S site, the control plot (12-204) provided the baseline for comparing the effectiveness of erosion control measures using five erosion control products: Product C (12-205), Product D (12-206), Product E (12-207), Product F (12-208), and Product G (12-209). The following sections summarize the observations made during the course of storm events between February 25 and April 21, 2001 at this site. The occurrence and approximate percentage cover of vegetation growth on the 55S site plots during 2000-2001 study storm season are summarized in Table 6.

<u>Control Plot (12-204)</u>

Figure 19 shows a time-series progression of the control plot (12-204) over the 2000-2001 study season. As previously discussed, the control plot at this location was approximately one-half the size of the other test plots at the 73S site for the February 26 and March 6, 2001 storm events. During the intense periods of rainfall, moderate sediment accumulation was observed in the flume and near the intake of the automatic sampler that impeded the accuracy of the level measurements obtained from the bubbler.

Shallow rill formation appeared to develop throughout the plot over the four storm events, with the greatest concentration of rills appearing in the southeastern portion of the test plot during the last event on April 21, 2001.

New vegetation appeared on the control test plot by the April 7, 2001 storm event. The vegetation density continued to increase over the remaining 2000- 2001 study season.

Product C (12-205)

Figure 20 shows a time-series progression of the Product C test plot. As previously stated, this plot appeared to have the highest runoff volume and sediment load of the six plots at the 73S study site. This may be attributed to and the lack of sufficient drying time after the first application; lack of product adherence to the slope and run off the plot during both applications.

Shallow rill formation was observed in the lower portion of the test plot during the April 7, 2001 storm event. During the April 21, 2001 storm event, shallow rill formation was observed throughout the entire test plot, with the deepest rills observed in the lower portion of the slope.

New vegetation appeared on the Product C test plot between the March 6 and April 7, 2001 storm events. The vegetation density continued to increase over the remaining 2000-2001 storm monitoring season.

Product D (12-206)

Figure 21 shows a time-series progression of the Product D test plot. Very little sediment accumulation was observed in the flume and intake of the automatic sampler during the storm events and sediment accumulation did not appear to affect flow measurements obtained from the Product D test plot.

Slight rill formation was observed in the central portion of the test plot during the April 7, 2001 storm event. During the April 21, 2001 storm event, shallow rill formation was observed throughout the test plot with the deepest rills observed on the lower, southeastern, and northwestern portions of the slope.

Small patches of vegetation appeared on the Product D test plot between the March 6 and April 7, 2001 storm events. The vegetation density continued to increase over the remaining 2000-2001 storm monitoring season.

Product E (12-207)

Figure 22 shows a time-series progression of the Product E test plot. During the February 26 and March 6 storm events, very little sediment accumulation was observed in the flume and intake of the automatic sampler. Sediment accumulation during these storm events did not appear to affect flow measurements obtained from the Product E test plot.

During the April 7 and April 21, 2001 storm events, moderate sediment accumulation was observed in the flume and near the intake of the automated sampler for this test plot. During periods of intense rainfall, the runoff appeared to be turbid and contained a significant amount of sediment. The sediment load impeded the accuracy of flow measurements.

Rill formation was observed in the upper northeastern and central portions of the test plot during the April 7, 2001 storm event. Product E appeared to have been washed off in small areas of the test plot. During the April 21, 2001 storm event, shallow rill formation was observed throughout the test plot with the deepest rills observed on the lower, southeastern, and northwestern portions of the slope.

New vegetation appeared on the Product E test plot between the March 6 and April 7, 2001 storm monitoring events. The vegetation density continued to increase over the remaining 2000- 2001 study season.

Product F (12-208)

Figure 23 shows a time-series progression of the Product F test plot. During the February 26 and March 6 storm events, very little sediment accumulation was observed in the flume and intake of the automatic sampler. Sediment accumulation during these storm events did not appear to affect flow measurements obtained from the Product F test plot. During the April 7 and April 21, 2001 storm events, major sediment accumulation was observed in the flume and near the intake of the automated sampler for this test plot. During periods of intense rainfall, the runoff appeared to be turbid and contained a significant amount of sandy sediment. The sediment load impeded the accuracy of flow measurements. Of the six plots at the 73S site, this test plot appeared to have the highest runoff volume and sediment load over the 2000-2001 study season.

Rill formation was observed in the lower right-central portion of this slope during the March 6, 2001 monitoring event and deepened and widened with subsequent storm events. Small (1- to 2-inch diameter) animal burrow holes were observed before the April 7, 2001 storm.

New vegetation appeared on the Product F test plot between the March 6 and April 7, 2001 storm events. The vegetation density continued to increase over the remaining 2000- 2001 storm monitoring season.

Product G (12-209)

Figure 24 shows a time-series progression of the Product G test plot. Very little sediment accumulation was observed in the flume and intake of the automatic sampler during the storm events; however, mulch from the application did accumulate in the v-ditch over the 2000-2001 storm monitoring season storm events. The mulch was cleared from the flume to allow more accurate flow measurements. Relative to the other five plots at this site, the Product G test plot appeared to have the lowest amount of runoff volume and sediment load over the 2000-2001 study season.

Rill formation was not observed on the Product G test plot during the course of the four storm monitoring events.

Small patches of vegetation appeared on the Product G test plot between the March 6 and April 7, 2001 storm monitoring events. The vegetation density continued to increase over the remaining 2000- 2001 study season.

5.4.2.2 Storm Water Quality Results

Stormwater samples were collected during four qualifying storm monitoring events at the 55S site. A total of 17 composite samples were collected from the 73S site during the 2000-2001 study season. The storm water quality runoff data for the 73S site are summarized in Table 7.

A discussion of the storm water quality runoff results as they relate to the soil and product sample results is presented in Section 6.0.

6.0 SUMMARY

The erosion performance and potential export of constituents for each of the tested products are discussed in the following subsections. A discussion of erosion performance is provided in Subsection 6.1. The potential export of constituents is discussed in Subsections 6.2 and 6.3. Product Performance Summaries for each of the tested products are provided in Section 6.4. These summaries include application and performance information. Product information and performance are summarized in Table 8.

6.1 EROSION PERFORMANCE

Primarily, erosion performance of the products was evaluated qualitatively using the results of visually monitoring the plots during and after each storm event. The total suspended solids (TSS) concentrations of the storm water runoff samples were also reviewed to see whether these results could be used to further evaluate erosion performance. Using TSS concentrations to help evaluate erosion performance may be appropriate, provided they correlate with the visual monitoring results. For comparison purposes, four visual monitoring categories (or scores) were selected to represent the erosion control performance observed for each product over each storm event. The scores range from 1 to 4, with a score of 1 assigned to plots with the least evidence of erosion and a score of 4 assigned to plots with the greatest amount of observed erosion. For each storm event, the erosion score of a plot was compared to the concentration of total suspended solids (TSS) in the storm water sample collected from that plot. Plots of erosion score against measurements of TSS are presented on Figures 25 and 26. Inspection of Figures 25 and 26 indicates there is some correlation between the visual monitoring results and TSS. However, there are also some cases where notable erosion was observed and the TSS concentrations were relatively low. Based on these apparent discrepancies, the TSS results were only used as a secondary means of evaluating erosion performance.

To compare the erosion control effectiveness of the products with the control plots and with each other, a ranking of “Low”, “Medium”, and “High” was formulated based on the visual monitoring results and to a lesser extent on the results of the TSS analyses. The criteria that define these rankings are provided below.

Erosion Control Performance - High

- no to very slight sediment load observed in v-ditch and flume during or after storm event;
- no to very minor (i.e., localized and very shallow) rill formation observed on plot after storm event;
- clearing sediment from intake of automatic sampler in v-ditch typically not required during storm; and
- measured TSS in storm water sample typically less than 400 ppm.

Erosion Control Performance - Medium

- low to moderate sediment load observed in v-ditch and flume during or after storm event;
- minor to moderate rill formation observed on plot after storm event, or further deepening and/or widening of existing rills; and
- occasional to periodic clearing of sediment from intake of automatic sampler in v-ditch typically required during intense portions of the storm event

Erosion Control Performance - Low

- moderate to high sediment load observed in v-ditch and flume during or after storm event;
- notable rill formation observed on plot after storm event or, further deepening and/or widening of existing rills;
- periodic to nearly constant clearing of sediment from intake of automatic sampler in v-ditch typically required during intense portions of the storm event; and
- measured TSS in storm water sample typically greater than 4,000 ppm

The products are evaluated in Table 8 and in the Product Performance Summaries in Section 6.4 using these defined rankings of erosion. Overall, the seven products on the test plots effectively reduced slope erosion compared to the control plots over the 2000-2001 storm season, or at least initially. Observations of the slopes at the two test sites indicate that the products tested in this study have different life spans. It should be noted that the March 6, 2001 storm event was of low intensity and produced minimal runoff from all plots at both sites. Consequently, there was no to minor erosion observed from the plots and the erosion performance from all plots was ranked as “High” for this storm event.

At the 73S site, Product F, Product E, and Product C appear to have limited effective life spans lasting less than one rainy season. Product E performed well for the first two storms and then declined thereafter. Products C and F typically performed well for one to two storm events and then their performance appeared to decline more than Product E thereafter. Conversely, Product D and Product G appear to have longer life spans. In general, observations of the plots at the 73S site indicate that Product G appeared to perform the best in controlling erosion over the entire 2000-2001 storm season.

At the 55S site, Product A and Product B performed well as erosion control measures. In general, these two products appeared to perform similarly in controlling erosion. It should be noted that Product A and Product B were subjected to one more significant storm event (February 12, 2001) than the 73S site, and caution should be used when comparing performance between sites.

6.2 EXPORT OF CONSTITUENTS

The results of the analytical testing indicate that some constituents were exported from some of the plots. A number of these constituents correlate with the export of total suspended solids. Export of constituents that correlate with the export of total suspended solids is referred to herein as erosion-related export. Export of several other constituents did not appear to be correlated with total suspended solids, but rather appeared specific to individual products or the plots on which the products were applied. This export is referred to herein as possible product-related export. The remaining constituents exported did not appear to be correlated to the products or to total suspended solids, but rather showed significant scatter in the limited data. Further testing of the seven products may indicate a relationship of these constituents with erosion-related export, product- related export, or some other factor. The following subsections discuss the erosion- and product-related exports.

6.2.1 Erosion-Related Export

For the following constituents, the concentrations in runoff correlate with concentrations of total suspended solids:

particle-bound aluminum[1]	particle-bound chromium	particle-bound manganese
particle-bound calcium	particle-bound copper	particle-bound nickel
particle-bound barium	total kjeldahl nitrogen	particle-bound vanadium
particle-bound cadmium	particle-bound lead	particle-bound magnesium
particle-bound iron	particle-bound potassium	particle-bound zinc

Figures 27 through 41 demonstrate generally good correlations between these constituents and total suspended solids. Given the number of these correlations, it appears that minimizing total suspended solids (TSS), by preventing erosion, will minimize the export of many of constituents identified during the 2000-2001 study season.

6.2.2 Possible Product-Related Export

For several constituents analyzed, concentrations in runoff were distinctly higher for one or more plots compared to other plots, in particular the bare plots, and were not correlated with total suspended solids. Identification of distinctly higher concentrations was by inspection; too few data are available to meaningfully apply statistical methods. Such distinctly higher concentrations were classified as possible cases of product-related export. For the following reasons, some uncertainty accompanies these cases. First, identification was by inspection, rather than by use of a statistical method. Second, the one-product-one-plot design confounds the differences between products with differences between the underlying soils in the different plots. An observed difference may be due to the product or it may be due to the underlying soil. Finally, several of the products are applied with mulches. The composition and/or rate of decomposition of the various mulches may account for the differences, rather than the products, which serve only as binders to hold the mulches together.

[1] Particle-bound concentrations were calculated by subtracting dissolved concentrations from their corresponding total concentrations. For example, the particle-bound aluminum concentration for Plot 12-204 in the storm on 2/26/01 (2,395 µg/l) was calculated by subtracting the dissolved aluminum concentration (339 µg/l) from the total aluminum concentration (2,734 µg/l).

6.2.2.1 Constituents

Based upon the storm events sampled during this study, higher concentrations that may represent product-related export were observed for the following constituents:

BOD	Nitrate
COD	Dissolved Potassium
DOC	Sulfate
TOC	Total Zinc

In order to assess the significance of the elevated concentrations for the above listed constituents, the detected concentrations are compared to the distribution of concentrations in runoff samples collected over the 1997 through 1999 wet seasons at construction sites for the Caltrans statewide characterization project. The results and data comparisons are discussed in the following subsections.

BOD, COD, DOC, and TOC

What appear to be distinctly higher concentrations of BOD, COD, DOC, and TOC were measured in runoff from Plot 12-207, which was treated with Product E containing mulch (Figures 42 through 45). The COD, DOC, and TOC measurements for Plot 12-207 may represent the same material exported from the plot. For each storm, the concentration of DOC is essentially the same as the concentration of TOC. The corresponding concentrations of COD appear to approximately track those of DOC and TOC. The concentrations of all three also rise with each succeeding storm, possibly the result of weathering of the product and/or the mulch, but may be due to decomposition in the soil of Plot 12-207. BOD for Plot 12-207 exhibits behavior opposite to the other three. It is highest for the first storm and is relatively low for succeeding storms.

As shown on Table 5, of all the product samples included in this study and submitted for chemical analysis, Product E had the second highest detected concentrations of COD, DOC, and TOC (2920 milligrams per liter (mg/l), 1190 mg/l, and 1200 mg/l, respectively) and the fourth highest BOD concentration (594 mg/l).

As shown in Figure 45, the detected COD concentrations fall between the approximate 50th and 95th percentile of the statewide construction results. The 50th percentile is the median concentration of the statewide results, i.e., half of the concentrations are less than or equal to the 50th percentile. The 95th percentile is the concentration that is greater than or equal to 95 percent of the statewide results. There are no statewide construction results for DOC, TOC, or BOD.

Nitrate

What appear to be distinctly higher concentrations of nitrate were detected in runoff samples from certain storms for Plots 12-203 and 12-207, which were treated with Product B and Product E/mulch, respectively (Figures 46 and 47). High nitrate concentrations were detected in samples collected from Plot 12-203 in the first storm and from Plot 12-207 in the third storm. Nitrate was not detected in either the Product B or Product E product samples submitted for analysis (Table 5).

As shown in Figure 46, for Product B, the nitrate concentration in the first storm was nearly as high as the 95th percentile of the statewide construction results. In the second storm, the nitrate concentration for the first sample set was between the 75th and 90th percentiles. The concentration was slightly lower than the 25th percentile for the second sample set of the same storm event, which was collected and analyzed on the second day of the storm event. As shown in Figure 47, for Product E, the nitrate concentrations in the first two storms were lower than the 10th percentile. However, in the third storm, the concentration was between the 90th and 95th percentiles. In the fourth storm, the concentration was between the 50th and 75th percentiles.

Dissolved Potassium

What appeared to be a distinctly higher concentration of dissolved potassium was measured in runoff during the first storm for Plot 12-203, which was treated with Product B (Figure 48). In the second storm, the potassium concentration was slightly, but not distinctly higher than for Plots 12-201 and 12-202. Chemical analysis of Product B (Table 5) indicates that the product contains potassium at a concentration of 1400 micrograms per liter (μg/l).

There are no statewide construction results for dissolved potassium.

Sulfate

Distinctly higher concentrations of sulfate were measured in runoff during the first storm on each of Plots 12-203 and 12-206, which were treated with Product B and Product D, respectively (Figure 49). During the third storm for the 73 site, sulfate concentrations were higher for all of the plots, including Plot 12-206, than in the first storm, suggesting that relatively high sulfate concentrations were present in the rain falling on the site. During the second storm for the 73S site, Plot 12-208, appeared to have a higher sulfate concentration;

however, for that storm the concentrations of all the plots, except Plot 12-206, were higher than the first storm, though not as high as the third storm.

Sulfate was detected at a concentration of approximately 60 milligrams per kilogram (mg/kg) in the Product B sample submitted for analysis (Table 5). Sulfate analysis on the Product D sample was not performed, however, the primary constituents in Product D include Plaster of Paris (which cures to gypsum), and gelatin (hydrolyzed keratin). Gypsum is calcium sulfate dihydrate and is modestly soluble in water. The appearance of sulfate in the runoff from Plot 206 during the first storm could be due to dissolution of the gypsum.

There were only three data points for sulfate in construction runoff statewide, which is insufficient to make a meaningful comparison.

Total Zinc

Although total zinc concentrations were correlated with total suspended solids, the total zinc concentration in runoff during the first storm for Plot 12-209, which was treated with Product G, was distinctly higher than the correlation would predict. The total zinc concentration in the first storm for Product G plot falls between the 75th and 90th percentile of the statewide construction characterization results (Figure 50). Chemical analysis of Product G (Table 5) indicates that the product contains zinc at a concentration of 480 micrograms per liter (μg/l), which was the second highest among the products.

Total zinc concentration in the third storm for Product E falls between the 90th and 95th percentile (Figure 50).

6.3 PRODUCT PERFORMANCE SUMMARIES

This section provides a separate summary of each product tested during the 2000-2001 storm season. The summaries provide an overview of the product and highlight the findings of study that are specific to the product.

PRODUCT PERFORMANCE SUMMARY
PRODUCT A
Caltrans Temporary
Soil Stabilization Study
2000-2001 Season

District 12 - 55S Orange County Study Site

The following is a summary of the performance of Product A as an erosion control product and its resultant effect, if any, on storm water quality during the 2000-2001 study season. It also includes the intended use and erosion control application; the recommended method for application including rate and drying time; and some general endurance qualities of Product A as an erosion control product. The findings of the field and laboratory evaluation of this product are also summarized.

Product A was applied to a field test plot (12-202) at the District 12, 55S Orange County Study Site at the intersection of the 55S and 73 freeways. The test plot was a 0.1acre, 2:1 (H:V) sloped highway embankment approximately 20 to 30 feet high. The slope was constructed of compacted fill consisting of sandy clay.

PRODUCT DESCRIPTION

Category Type: Polyacrylamide/Acrylate
Chemical Makeup: 30 percent anionic polyacrylamid/ammonium acrylate in water-in-oil emulsion
Physical Properties: Grayish-white, viscous emulsion; faint ammonia odor; pH 6 to 8 (upon dilution in water)

RECOMMENDED PRODUCT USE

Product A has a high molecular weight and specific charge density, which enhances soil particle aggregation. The product can be applied for temporary erosion control lasting up to one season. The actual length of the product effectiveness is dependent upon a number of factors including application, climate, slope inclination, and soil/geologic conditions.

According to the manufacturer, Product A is effective for erosion control, slope stabilization, dust abatement, storm water run-off, silt control, and water quality control. The product is not intended for vehicular traffic; however, it can be effective for dust suppression along roadways.

RECOMMENDED APPLICATION METHOD, RATE, AND DRYING TIME

Product A is typically applied as a spray to the soil surface. For erosion and sedimentation control, the manufacturer recommends the product be mixed with a mulch and a minimum of 3,000 gallons of water per acre. The actual amount of product used in the mixture is dependent upon the inclination of the slope to be treated. The product can be applied in any weather; however, field conditions that result in runoff of product during application should be avoided when possible.

FINDINGS

The performance of Product A on the test plot was monitored during a portion of the 2000-2001 wet season. Representative samples of storm water runoff were collected and analyzed from three storm events producing runoff from the test plot and the results were compared to results from an untreated control plot (12-201) consisting of bare soil. In addition, visual monitoring of erosion control performance was conducted during and after five storm events. The following summaries the findings related to erosion control performance and potential water quality impacts from Product A.

- The three storms in which composite samples were collected during the 2000-2001 study season had total rainfall amounts of 1.35, 1.81, and 0.31 inches with corresponding average intensities of 0.131, 0.04, and 0.068 inches per hour.

- Using the erosion control performance ranking criteria, the qualitative evaluation of erosion control performance for Product A was “High” for the five storms monitored. The total suspended solids concentration of runoff samples collected from the Product A plot were approximately one-one hundredth the concentration for the adjacent untreated control plot.

- Based on visual inspection of the storm water analytical results, no apparent product related export was noted in runoff samples collected from the Product A test plot during the 2000-2001 study season; however, foaming was noted in the runoff during the first storm event.

- The life span of Product A product appears to be longer than the five storm events monitored during the 2000-2001 study season.

PRODUCT PERFORMANCE SUMMARY
PRODUCT B
Caltrans Temporary
Soil Stabilization Study
2000-2001 Season

District 12 - 55S Orange County Study Site

The following is a summary of the performance of Product B as an erosion control product and its resultant effect, if any, on storm water quality during the 2000-2001 study season. It also includes the intended use and erosion control application; the recommended method for application including rate and drying time; and some general endurance qualities of Product B as an erosion control product. The findings of the field and laboratory evaluation of this product are also summarized.

Product B was applied to a field test plot (12-203) at the District 12, 55S Orange County Study Site at the intersection of the 55S and 73 freeways. The test plot was a 0.1acre, 2:1 (H:V) sloped highway embankment approximately 20 to 30 feet high. The slope was constructed of compacted fill consisting of clayey sand.

PRODUCT DESCRIPTION

Category Type: Acrylic Vinyl Acetate Polymer
Chemical Makeup – Aqueous acrylic vinyl acetate polymer emulsion
Physical Properties – Milky white liquid; characteristic acrylic odor; pH 4.0 to 9.5

RECOMMENDED PRODUCT USE

Product B is used primarily for soil stabilization and as a dust control agent. This product is not generally used to support vehicular traffic.

RECOMMENDED APPLICATION METHOD, RATE, AND DRYING TIME

Product B is designed to be applied as a spray using a standard water truck or used as a tackifer during hydroseeding. The amount of Product B applied to a site is dependent upon soil texture and slope. At the study site, Product B was applied by the manufacturer at a rate of 670 gallons per acre or about 1 gallon per 65 square feet. Product B is most effective if applied on either dry or slightly moist soil. Excessive moisture will dilute the application rate. Drying time is dependent upon weather conditions including temperature, humidity and wind. Typical drying times may be 8 hours for an overcast day and 2 hours on a sunny day.

FINDINGS

The performance of the Product B test plot was monitored during a portion of the 2000/2001 wet season. Representative samples of storm water runoff were collected and analyzed from two storm events producing sufficient runoff from the test plot and the results were compared to results from an untreated control plot (12-201) consisting of bare soil. In addition, visual monitoring of erosion control performance was conducted during and after five storm events. The following summarizes the findings related to erosion control performance and potential water quality impacts from Product B.

- The two storms in which composite samples were collected during the 2000-2001 study season had total rainfall amounts of 1.32 and 1.78 inches with corresponding average intensities of 0.13 and 0.04 inches per hour.

- Using the erosion control performance ranking criteria, the qualitative evaluation of erosion control performance from the Product B test plot was “High” for the five storms monitored. The total suspended solids concentration of runoff samples collected from the Product B plot were approximately one-one hundredth the concentration for the adjacent untreated control plot.

- What appeared to be a distinctly higher sulfate concentration was measured in runoff during the first storm from the plot treated with Product B. Sulfate was detected at a concentration of approximately 60 milligrams per kilogram (mg/kg) in the Product B sample submitted for analysis.

- The life span of Product B appears to be longer than the five storms monitored during the 2000-2001 study season.

PRODUCT PERFORMANCE SUMMARY
PRODUCT C
Caltrans Temporary
Soil Stabilization Study
2000-2001 Season

District 12 - 73S Orange County Study Site

The following is a summary of the performance of Product C as an erosion control product and its resultant effect, if any, on storm water quality during the 2000-2001 study season. It also includes the intended use and erosion control application; the recommended method for application including rate and drying time; and some general endurance qualities of Product C as an erosion control product. The findings of the field and laboratory evaluation of this product are also summarized.

Product C was applied to a field test plot (12-205) at the Caltrans District 12, 73S Orange County Study Site approximately one mile south of Newport Coast Drive on the southbound Highway 73. The product was applied to the slope on two separate occasions. In both applications, Product C was applied without mulch, which according to the manufacturer, is an acceptable method. Precipitation within about two hours after the first application did not allow ample drying time, and prevented the product from completely drying and adhering to the slope. Consequently, Product C was reapplied under dry climatic conditions, allowing the product to thoroughly dry. However, during both applications, it was observed that a portion of the product did not adhere to the slope and ran off the plot.

The test plot was a 0.2 acre, 2:1 (H:V) sloped highway embankment approximately 55 feet high. The slope was constructed of a compacted fill consisting of silty sand.

PRODUCT DESCRIPTION

Category Type: Hydro-colloid polymer
Chemical Makeup: Polyacrylamide and copolymer of acrylamide
Physical Properties: Light Green; no odor; pH 7.0

RECOMMENDED PRODUCT USE
Product C is used as tackifier for binding mulch and seed during hydroseeding operations. The product is often used to aid in establishment of vegetation; however, it can be used with or without mulch as a temporary soil erosion control measure.

RECOMMENDED APPLICATION METHOD, RATE, AND DRYING TIME

Product C is sprayed on using a hydroseeding machine. Application rates when using mulch or when applying the product alone are dependent upon the inclination of the slope. Product C was applied on test plot (12-205) at a mix ration of 16 pounds of product and 500 gallons of water. This ratio equates to about 80 pounds per acre and about 2,500 gallons. Drying time for Product C is about 2 to 4 hours and is dependent on existing climatic conditions. The product should be applied on dry to moist surface conditions and should not be applied in the rain.

FINDINGS

The performance of the Product C test plot was monitored during a portion of the 2000-2001 wet season. Representative samples of storm water runoff were collected and analyzed from three storm events producing runoff from the test plot and the results were compared to results from an untreated control plot (12-204) consisting of bare soil. In addition, visual monitoring of erosion control performance was conducted during and after four storm events. The following summarizes the findings related to erosion control performance and potential water quality impacts for Product C.

- The three storms in which composite samples were collected during the 2000-2001 study season had total rainfall amounts of 2.18, 0.63, and 0.31 inches with corresponding average intensities of 0.064, 0.058, and 0.121 inches per hour.

- Product C was applied on the test plot twice during this study. In both cases, the product was applied without mulch, which according to the manufacturer is an acceptable method for application. However, the amount of product remaining on the slope after application appeared very limited. In the case of the first application, the product may have not fully cured and may have washed from the slope during the first storm event. In the second case, it appeared that some of the product did not adhere to the slope surface and ran off during application. Based on these observations, it appears that this product should not be used on a 2:1 slope surface without mulch.

- Using the erosion control performance ranking criteria, the qualitative evaluation of erosion control for the Product C test plot was “Low” for three of the four storm events monitored. The total suspended solids concentrations in runoff water collected from the test plot generally were comparable to the adjacent untreated control plot. However, the amount of product remaining on the slope after both applications appeared limited and its poor erosion performance during this study may be the result of not including a mulch with application.

- Based on a visual inspection of the storm water analytical results, no apparent product related export was noted in runoff samples collected from the Product C plot during the 2000-2001 study season.

PRODUCT PERFORMANCE SUMMARY
PRODUCT E
Caltrans Temporary
Soil Stabilization Study
2000-2001 Season

District 12 - 73S Orange County Study Site

The following summarizes the performance of Product E as an erosion control product and its resultant effect, if any, on storm water quality during the 2000-2001 study season. It also includes the intended use and erosion control application; the recommended method of application including rate and drying time; and some general endurance qualities of Product E as an erosion control product. The findings of the field and laboratory evaluation of this product are also summarized.

Product E was applied to a field test plot (12-207) at the District 12, 73S Orange County Study Site approximately one mile south of Newport Coast Drive on the southbound 73 Freeway. The test plot was a 0.2 acre, 2:1 (H:V) sloped highway embankment approximately 55 feet high. The slope was constructed of fill consisting of silty sand.

Product Description

Category Type: Polyacrylamide
Chemical Makeup: 18 mole percent anionic polyacrylamide powder, sodium salt
Physical Properties: Off-white granular solid

Recommended Product Use
Product E is an anionic polyacrylamide that is typically used as a tackifier and binding agent that can last as long as six months. The product is typically mixed with mulch and a hydroseed mixture and sprayed on the ground surface to improve seed germination and quicker plant establishment.

Recommended Application Method, Rate, and Drying Time
Product E is applied as a liquid spray with a hydroseeding machine. The mixing ratio is about 3 to 5 pounds per acre mixed with about 1,600 pounds of mulch and about 3,000 gallons of water. For the 2000-2001 study season, Product E was applied to a 0.2-acre test plot at a mix

ratio of 5 pounds of product, 325 pounds of mulch and 600 gallons of water. The product application rate used was approximately 25 pounds per acre, which was slightly higher than the rate recommended by the manufacturer because the product was being evaluated as an erosion control product rather than a tackifier or bonding agent. Product E requires about 2 to 4 hours to dry; however, this time is dependent upon temperature, humidity and wind.

Findings

The performance of the Product E test plot treated was monitored during a portion of the 2000/2001 wet season. Representative samples of storm water runoff were collected and analyzed from four storm events producing runoff from the test plot and the results were compared to results from an untreated control plot (12-204) consisting of bare soil. In addition, visual monitoring of erosion control performance was conducted during and after each of the four storm events. The following summarizes the findings related to erosion control performance and potential water quality impacts for Product E.

- The four storms monitored during the study had total rainfall amounts of 2.34, 0.43, 0.71, and 0.32 inches with corresponding average intensities of 0.068, 0.097, 0.061 and 0.128 inches per hour.

- Using the erosion control performance ranking criteria, the qualitative evaluation of erosion control for the Product E test plot was "High" for the first and second storms, and "Medium" for the third and fourth storm events. The total suspended solids concentrations in runoff water collected from the test plot were approximately one-one hundredth the concentration of the adjacent untreated control plot.

- Possible product-related export of BOD, COD, DOC and nitrate were noted in storm water runoff samples collected from the Product E test plot. Analysis of Product E for BOD, COD, DOC, and TOC indicate that these constituents are present in Product E at concentrations that are somewhat higher than or comparable to the other products tested. The source of these constituents may be the product, but also could be the particular mulch used or the underlying soil in the Product E plot. No nitrate was detected in Product E; however, nitrate appeared in later storms suggesting that it may have been generated by decomposition and oxidation of ammonia or organic nitrogen.

- The COD concentrations from the Product E test plot fall between the 50th and 95th percentile of the Caltrans statewide construction monitoring results. There are no statewide construction monitoring results for DOC, TOC, or BOD. The nitrate concentrations for the third and fourth storms were between the 50th and 95th percentiles.

- Based on the observed erosion control effectiveness, the life span of Product E appeared to be approximately the first two storms of the 2000-2001 study season.

PRODUCT PERFORMANCE SUMMARY
PRODUCT D
Caltrans Temporary
Soil Stabilization Study
2000-2001 Season

District 12 - 73S Orange County Study Site

The following is a summary of the performance of Product D as an erosion control product and its resultant effect, if any, on storm water quality during the 2000-2001 study season. It also includes the intended use and erosion control application; the recommended method for application including rate and drying time; and some general endurance qualities of Product D as an erosion control product. The findings of the field and laboratory evaluation of this product are also summarized.

Product D was applied to a field test plot (12-206) at the Caltrans District 12, 73S Orange County Study Site approximately one mile south of Newport Coast Drive on the southbound Highway 73. The test plot was a 0.2 acres, 2:1 (H: V) sloped highway embankment approximately 55 feet high. The slope was constructed of compacted fill consisting of silty sand.

Product Description
Category Type: Gypsum
Chemical Makeup: Mixture of plaster of paris and hydrolyzed keratin (calcium sulfate hemihydrate).
Physical Properties: Off-white to gray powder; low odor; pH 7.5 to 8.5.

Recommended Product Use
Product D is cementious plaster binder produced from high-purity gypsum and applied in conjunction with a cellulose or wood fiber mulch through a hydraulic process. The product forms a uniform protective crust-like barrier that reduces water and wind induced erosion. Product D is typically used for erosion control and as a cover for establishing vegetation on disturbed slope areas.

Recommended Application Method, Rate, and Drying Time

Product D is typically applied as a part of a bonded fiber matrix consisting of water, and cellulose or wood fiber. The manufacturer recommends a mix ratio of 6,000 pounds of Product D, 1,600 pounds of mulch fiber and 4,000 gallons of water per acre. The product is typically applied to slopes of 4:1 or greater and is sprayed uniformly over the area to be treated using a hydroseeder/hydromulcher. For the 2000-2001 study season, the product was applied on an approximately 0.2 acre test plot using a hydroseeding machine at a mix ratio recommended by the manufacturer of 1,000 pounds of Product D, 300 pounds of fiber mulch, and 600 gallons of water. The product should be not be applied during rain events, to excessively moist soil, or when wind gusts exceed 25 miles per hour. Product drying time is between 4 and 8 hours, but is dependent upon temperature, humidity, and wind.

Findings

The performance of the Product D test plot was monitored during a portion of the 2000/2001 wet season. Representative samples of storm water runoff were collected and analyzed from two storm events producing runoff from the test plot and the results were compared to results from an untreated control plot (12-204) consisting of bare soil. In addition, visual monitoring of erosion control performance was conducted during and after the four storm events. The following summarizes the findings related to erosion control performance and potential water quality impacts for Product D.

- The two storms in which composite samples were collected during the 2000-2001 study season had total rainfall amounts of 2.17 and 0.30 inches with corresponding peak average intensities of 0.065 and 1.12 inches per hour.

- Using the erosion control performance ranking criteria, the qualitative evaluation of erosion control for the Product D test plot was "High" for the four storm events monitored. The total suspended solids concentrations in runoff water collected from the test plot were approximately one-one hundredth the concentration of the adjacent untreated control plot.

- Possible product-related export of sulfate from the Product D test plot was noted during the first storm event. The appearance of sulfate in the runoff from the Product D plot could be due to the dissolution of gypsum (Plaster of Paris), which is the primary constituent in Product D.

- The life span of the Product D appears to be longer than the four storm events monitored during the 2000-2001 study season.

PRODUCT PERFORMANCE SUMMARY
PRODUCT F

Caltrans Temporary
Soil Stabilization Study
2000-2001 Season

District 12 - 73S Orange County Study Site

The following is a summary of the performance of Polyacrylamide (Product F) as an erosion control product and its resultant effect, if any, on storm water quality during the 2000-2001 study season. It also includes the intended use and erosion control application; the recommended method for application including rate and drying time; and some general endurance qualities of Product F as an erosion control product. The findings of the field and laboratory evaluation of this product are also summarized.

Product F product was applied to a field test plot (12-208) at the District 12, 73S Orange County Study Site approximately one mile south of Newport Coast Drive on the southbound 73. The test plot was a 0.2 acre, 2:1 (H:V) sloped highway embankment approximately 55 feet high. The slope was constructed of compacted fill consisting of silty sand.

PRODUCT DESCRIPTION

Category Type: Polyacrylamide
Chemical Makeup: Anionic polyacrylamide – high molecular weight (15mg/mole) and high anionic charge density.
Physical Properties: Off-white granular powder; no discernible odor.

RECOMMENDED PRODUCT USE

Product F is a long-chain organic polymer developed to clarify drinking water. Product F has also been used for erosion control, enhanced infiltration and nutrient removal. The product has become utilized for erosion control because of it ability to conveniently and inexpensively stabilize soils and remove fine suspended sediments from storm water.
If the treated area is disturbed by foot and/or vehicle traffic the product will not be effective and will need to be reapplied.

Recommended Application Method, Rate, and Drying Time

Product F can be applied as a dry form or as a liquid. In a dry form Product F can be applied using a seeder or fertilizer spreader. In a liquid form Product F is applied using a water truck or sealed hydro spray rig. According to recommendations from Washington Department of Transportation, Product F should be applied at a rate not to exceed 0.5 pounds per acre mixed in 1,000 gallons of water. The recommended dry product application rate is about five to ten pounds per acre; however, this method of applying the product is less desirable and considerably less effective than spraying. Product F may need to be reapplied to a site several times throughout the rainy season. According to recommendations by the Washington Department of Transportation, Product F should not be applied more than once in a 48-hour period and the maximum number of applications of Product F shall not exceed 7 in any 30-day period.

Findings

The performance of the Product F test plot was monitored during a portion of the 2000/2001 wet season. Representative samples of storm water runoff were collected and analyzed from three storm events producing runoff from the test plot and the results were compared to results from an untreated control plot (12-204) consisting of bare soil. In addition, visual monitoring of erosion control performance was conducted during and after four storm events. The following summarizes the findings related to erosion control performance and potential water quality impacts from Product F.

- The three storms in which composite samples were collected during the 2000-2001 study season had total rainfall amounts of 2.26, 0.62, and 0.28 inches with corresponding average intensities of 0.066, 0.057, and 0.131 inches per hour.

- Using the erosion control performance ranking criteria, the qualitative evaluation of erosion control for the Product F test plot was “High” for the first two storms and “Low” for the remaining two storms. After the first storm event, the total suspended solids concentration of runoff samples collected from the Product F plot were comparable to the concentrations from the untreated control plot.

- Possible product-related export of sulfate from the Product F test plot was noted in runoff samples collected during the second storm event.

- The life span of Product F product appeared to be limited to approximately the first storm event during the 2000-2001 study season.

PRODUCT PERFORMANCE SUMMARY
Product G
Caltrans Temporary
Soil Stabilization Study
2000-2001 Season

District 12 - 73S Orange County Study Site

The following is a summary of the performance of Product G as an erosion control product and its resultant effect, if any, on storm water quality during the 2000-2001 study season. It also includes the intended use and erosion control application; the recommended method for application including rate and drying time; and some general endurance qualities of Product G as an erosion control product. The findings of the field and laboratory evaluation of this product are also summarized.

Product G was applied to a field test plot (12-209) at the Caltrans District 12, 73S Orange County Study Site approximately one mile south of Newport Coast Drive on the southbound Highway 73. The test plot was a 0.2 acres, 2:1 (H: V) sloped highway embankment approximately 55 feet high. The slope was constructed of compacted fill consisting of silty sand.

PRODUCT DESCRIPTION

Category Type: Cellulose Fiber
Chemical makeup: Cellulose Based Fibers with proprietary filler
Physical properties: Finely divided material; tan in color; no discernible odor; pH 8.6.

RECOMMENDED PRODUCT USE

Product G is designed to be used as a daily cover material for landfills. However, representatives of the manufacturer reported that the product has also been used as an effective erosion control measure and suggested that it be included in this study. The manufacture reports that a single application of Product G near Phoenix, Arizona has been effectively controlling erosion for two seasons. Because it is a paper product, the durability of the product is limited and vehicular traffic should be avoided.

RECOMMENDED APPLICATION METHOD, RATE, AND DRYING TIME

Product G is applied using a hydrospray machine. The recommended product application rate is 3,500 pounds of material with 5,000 gallons of water per acre. A single bale of Product G weighs about 50 pounds. Product G was applied for the 2000-2001 study season over an area of about 0.2 acres at a rate of about 700 pounds of product and 1000 gallons of water.

FINDINGS

The performance of the Product G test plot was monitored during a portion of the 2000-2001 wet season. Representative samples of storm water runoff were collected and analyzed from two storm events producing runoff from the test plot and the results were compared to results from an untreated control plot (12-204) consisting of bare soil. In addition, visual monitoring of erosion control performance was conducted during and after four storm events. The following summarizes the findings related to erosion control performance and potential water quality impacts from Product G.

- The two storms in which composite samples were collected during the 2000-2001 study season had total rainfall amounts of 2.45 and 0.64 inches with corresponding average intensities of 0.07 and 0.06 inches per hour.

- Using the erosion control performance ranking criteria, the qualitative evaluation of erosion control for the Product G test plot was "High" for the four storms monitored. The total suspended solids concentration of runoff samples collected from the Product G plot were between one-tenth and one-one hundredth the concentration for the untreated control plot.

- Possible product-related export of total zinc from the Product G test plot was noted in runoff samples collected during the first storm event. Chemical analysis of the product indicates that Product G contains zinc at a concentration of 480 micrograms per liter.

- The detected zinc concentration from the first storm for the Product G plot falls between the 75^{th} and 90^{th} percentile of the Caltrans statewide construction monitoring results.

- The life span of Product G product appears to be longer than the four storm events monitored during the 2000-2001 study season.

7.0 REFERENCES

Brown and Caldwell, 1998, Statewide Roadside Erosion Review, prepared for California Department of Transportation, Sacramento, California, July

California Department of Transportation, 2000, Guidance Manual: Storm Water Monitoring Protocol, Second edition, July.

California Department of Transportation, 2001, Sampling and Analysis Plan, Caltrans Temporary/Permanent Soil Stabilization Evaluation Study (CTSW – RT-01-001), prepared for California Department of Transportation, Sacramento, California, March.

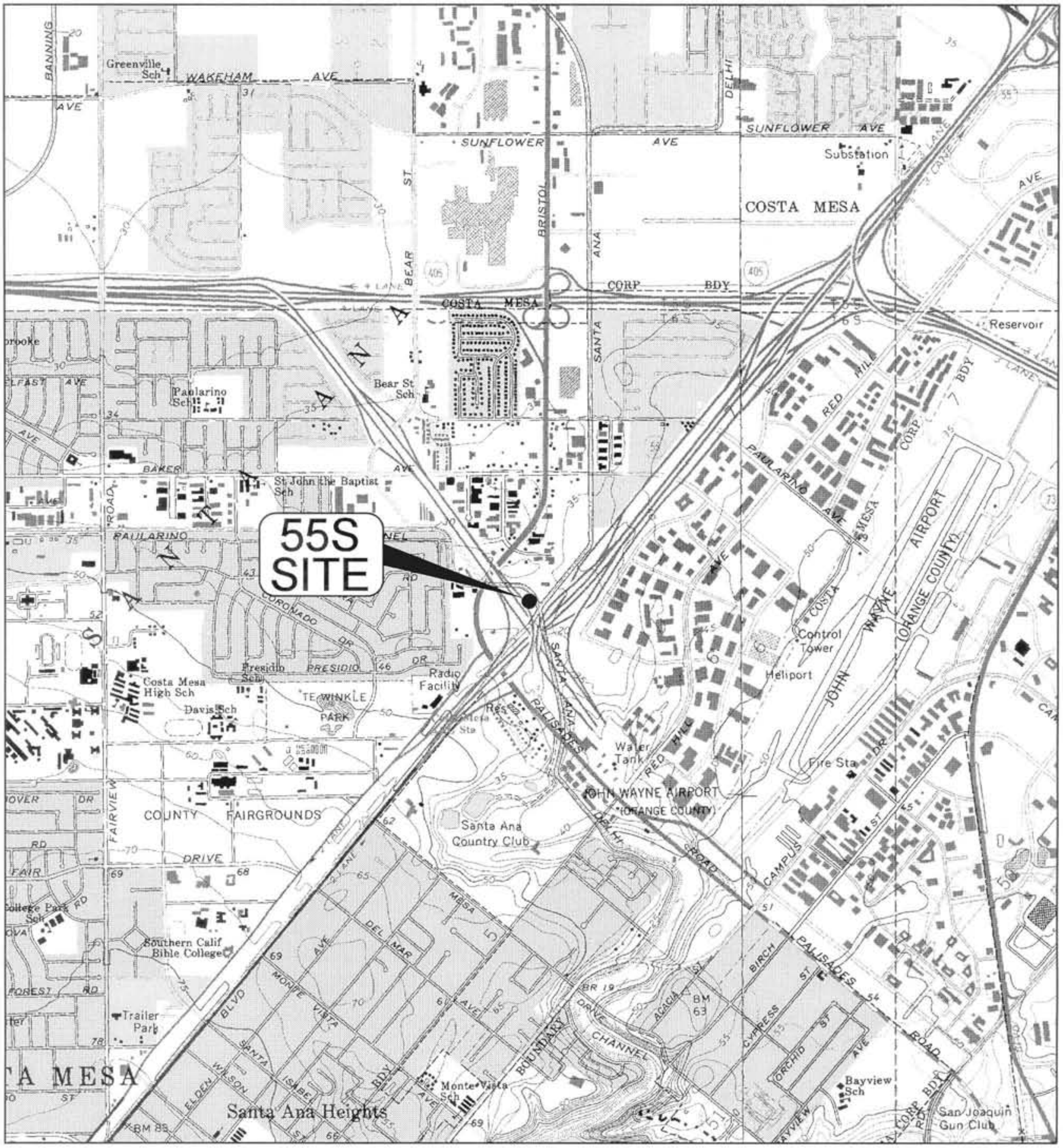
California Department of Transportation, 2001, Detailed Study Plan and Experimental Design, Caltrans Temporary/Permanent Soil Stabilization Evaluation Study, (CTSW-RT-01-014), prepared for California Department of Transportation, Sacramento, California, March.

California Department of Transportation, 2000, Caltrans District 7 Erosion Control Pilot Study, prepared for California Department of Transportation, Sacramento, California, June.

California Department of Transportation, 2000, Soil Stabilization for Temporary Slopes, prepared for California Department of Transportation, Sacramento, California, June.

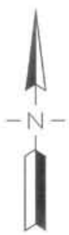
Woodward Clyde, 1998, District 7 Erosion Control Pilot Study: Detailed Study Plan and Experimental Design, prepared for California Department of Transportation, Sacramento, California.

FIGURES



Basemap modified from U.S.G.S. 7.5 minute Quadrangle Map
Laguna Beach 1965, California. Photo-revised 1981.
Newport Beach 1965, California. Photo-revised 1981.
Tustin 1965, California. Photo-revised 1981.

55S SITE LOCATION MAP Temporary Non-Vegetative Soil Stabilization Evaluation Study	Figure By pah	Project No. 5865.003
	Date 10/25/01	Figure 1



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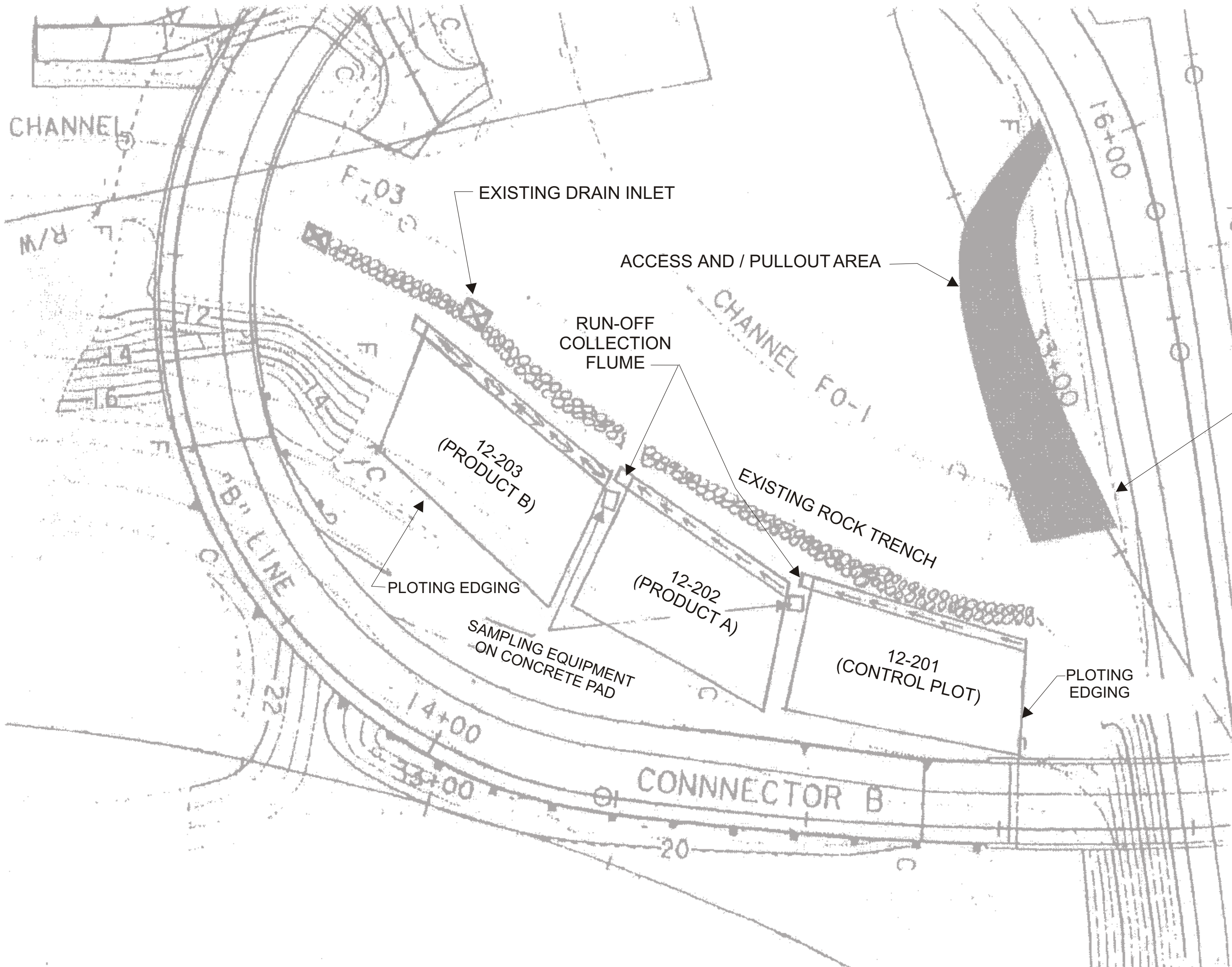
APPROXIMATE SCALE IN FEET

73S SITE LOCATION MAP

Temporary Non-Vegetative
Soil Stabilization Evaluation Study

Figure By	Project No.
pah	5865.003
Date	Figure
10/25/01	2

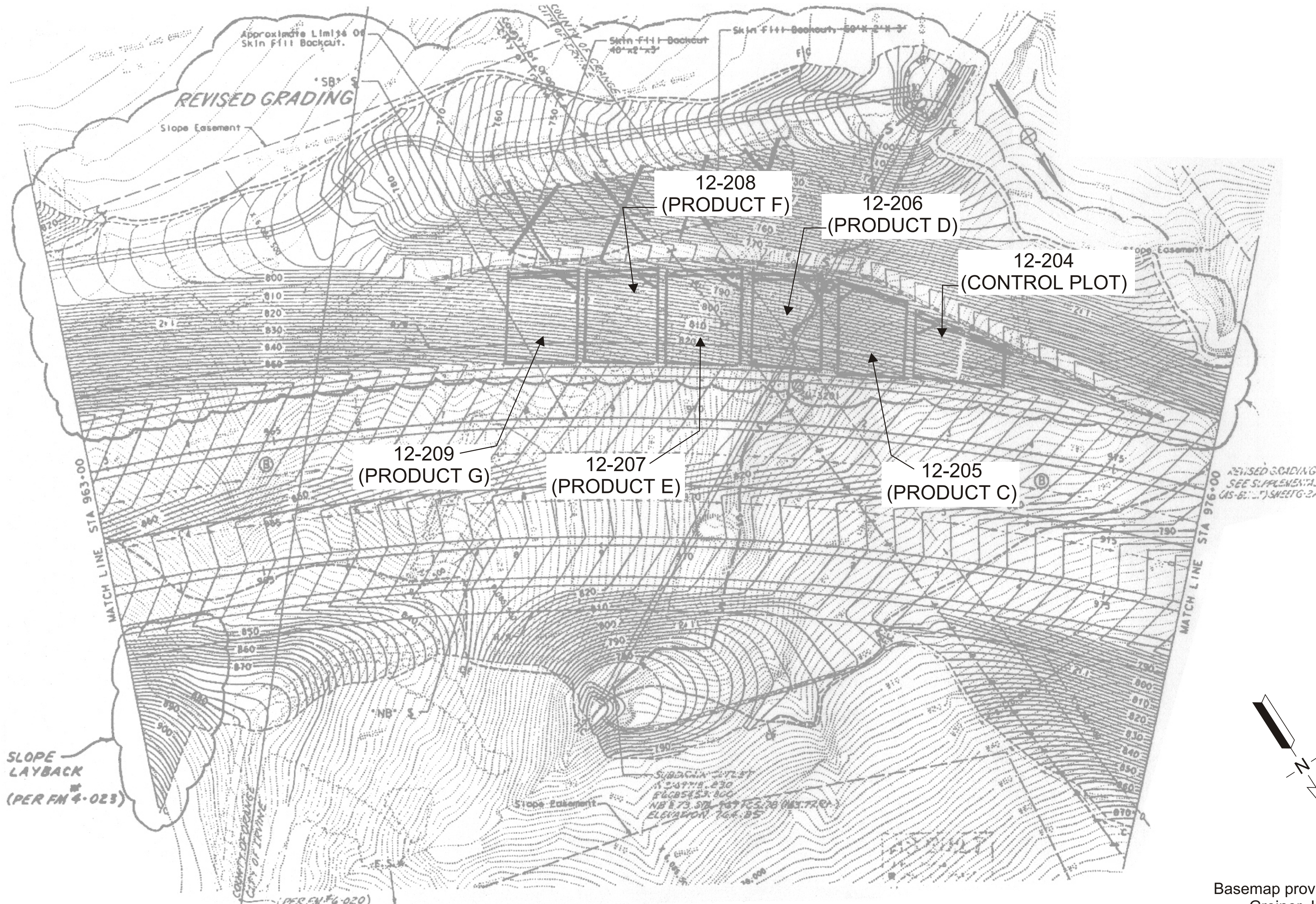


Basemap provided by:
Greiner, Inc.

55S SITE LAYOUT

Temporary Non-Vegetative
Soil Stabilization Evaluation Study

Figure by AY	Project No. 5865.003
Date 02/12/02	Figure 3



Basemap provided by:
Greiner, Inc.

73S SITE LAYOUT

Temporary Non-Vegetative
Soil Stabilization Evaluation Study

Figure by	Project No.
AY	5865.003
Date	Figure
02/12/02	4

PRE-CONSTRUCTION SLOPE WITH ROCK TRENCH IN FOREGROUND
(JANUARY 18, 2001)

TRACKING AND GRADING SLOPE
(JANUARY 19, 2001)

V-DITCH CONSTRUCTION
(JANUARY 12, 2001)

PLASTIC PANEL INSTALLATION
(JANUARY 23, 2001)

V-DITCH WITH FLUME (BACKGROUND)
(JANUARY 25, 2001)

CLOSE-UP OF FLUME
(JANUARY 25, 2001)

SITE CONSTRUCTION FOR
PLOTS 12-201 TO 12-203 (55S SITE)
Temporary Non-Vegetative
Soil Stabilization Evaluation Study

Figure by		Figure
AY		
Date	Project No.	5
02/12/02	5865.003	

PRE-CONSTRUCTION
(JANUARY 10, 2001)

FOLLOWING CLEARING AND GRUBBING
(FEBRUARY 7, 2001)

V-DITCH EXCAVATION
(FEBRUARY 7, 2001)

V-DITCH CONSTRUCTION
(FEBRUARY 15, 2001)

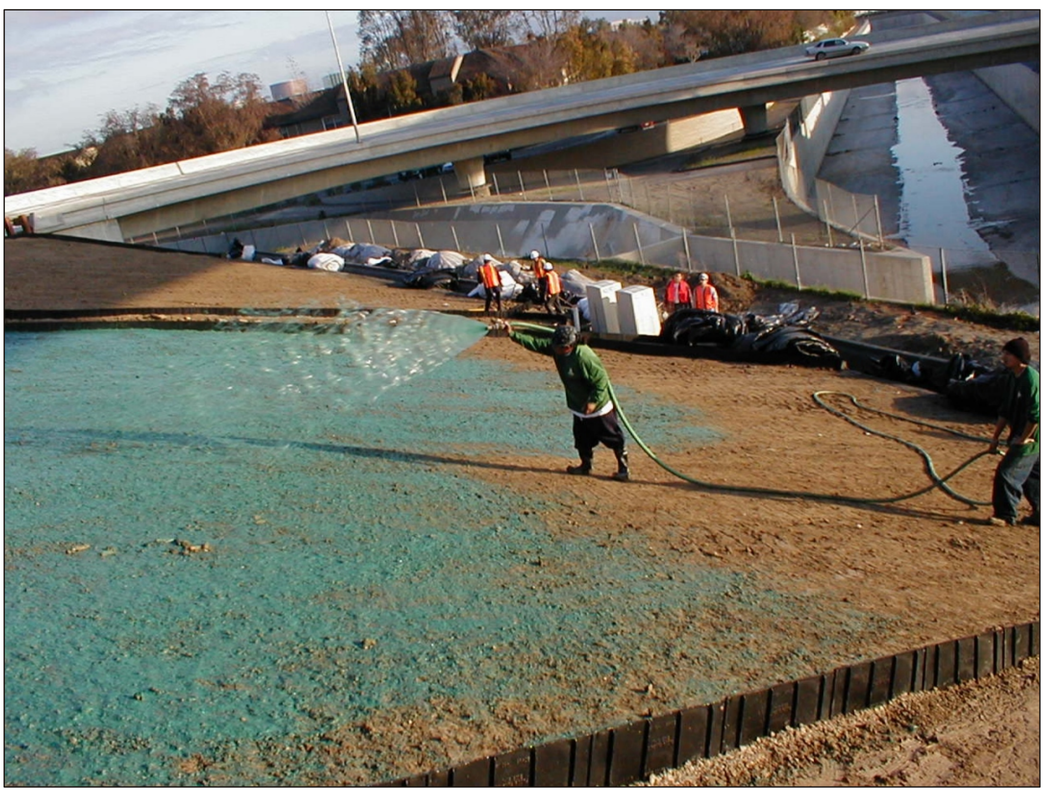
VIEW OF 12-201 SHOWING PLASTIC PANELS,
EQUIPMENT PADS, V - DITCH, AND FLUME
(FEBRUARY 20,2001)

PANORAMIC VIEW OF COMPLETED 73S SITE

SITE CONSTRUCTION FOR
PLOTS 12-204 TO 12-209 (73S SITE)
Temporary Non-Vegetative
Soil Stabilization Evaluation Study

Figure by		Figure
AY		6
Date	Project No.	
02/12/02	5865.003	

PRODUCT BEING APPLIED TO 12-202
(JANUARY 29, 2001)



PRODUCT BEING APPLIED TO 12-202
(JANUARY 29, 2001)

PRODUCT A (12-202)

PRODUCT APPLICATION

Temporary Non-Vegetative Soil Stabilization Evaluation Study

Figure by AY	Project No. 5865.003
Date 02/12/02	Figure 7

PRODUCT BEING APPLIED TO 12-203
(JANUARY 29, 2001)

PRODUCT BEING APPLIED TO 12-203
(JANUARY 29, 2001)

PRODUCT B (12-203)

PRODUCT APPLICATION
Temporary Non-Vegetative Soil Stabilization Evaluation Study

Figure by AY	Project No. 5865.003
Date 02/12/02	Figure 8

PRODUCT BEING APPLIED TO 12-205
(FEBRUARY 24, 2001)

COMPLETED PRODUCT APPLICATION FOR 12-205
(FEBRUARY 24, 2001)

PRODUCT C (12-205)

PRODUCT APPLICATION

Temporary Non-Vegetative Soil Stabilization Evaluation Study

Figure by AY	Project No. 5865.003
Date 02/12/02	Figure 9

PRODUCT BEING APPLIED TO 12-206
(FEBRUARY 22, 2001)

PRODUCT BEING APPLIED TO 12-206
(FEBRUARY 22, 2001)

PRODUCT D (12-206) PRODUCT APPLICATION Temporary Non-Vegetative Soil Stabilization Evaluation Study	Figure by AY	Project No. 5865.003
	Date 02/12/02	Figure 10

PRODUCT BEING APPLIED TO 12-207
(FEBRUARY 21, 2001)

PRODUCT BEING APPLIED TO 12-207
(FEBRUARY 21, 2001)

	PRODUCT E (12-207) PRODUCT APPLICATION Temporary Non-Vegetative Soil Stabilization Evaluation Study	Figure by AY Date 02/12/02	Project No. 5865.003 Figure 11

CONDITION OF PLOT 12-208
ON MARCH 7, 2001

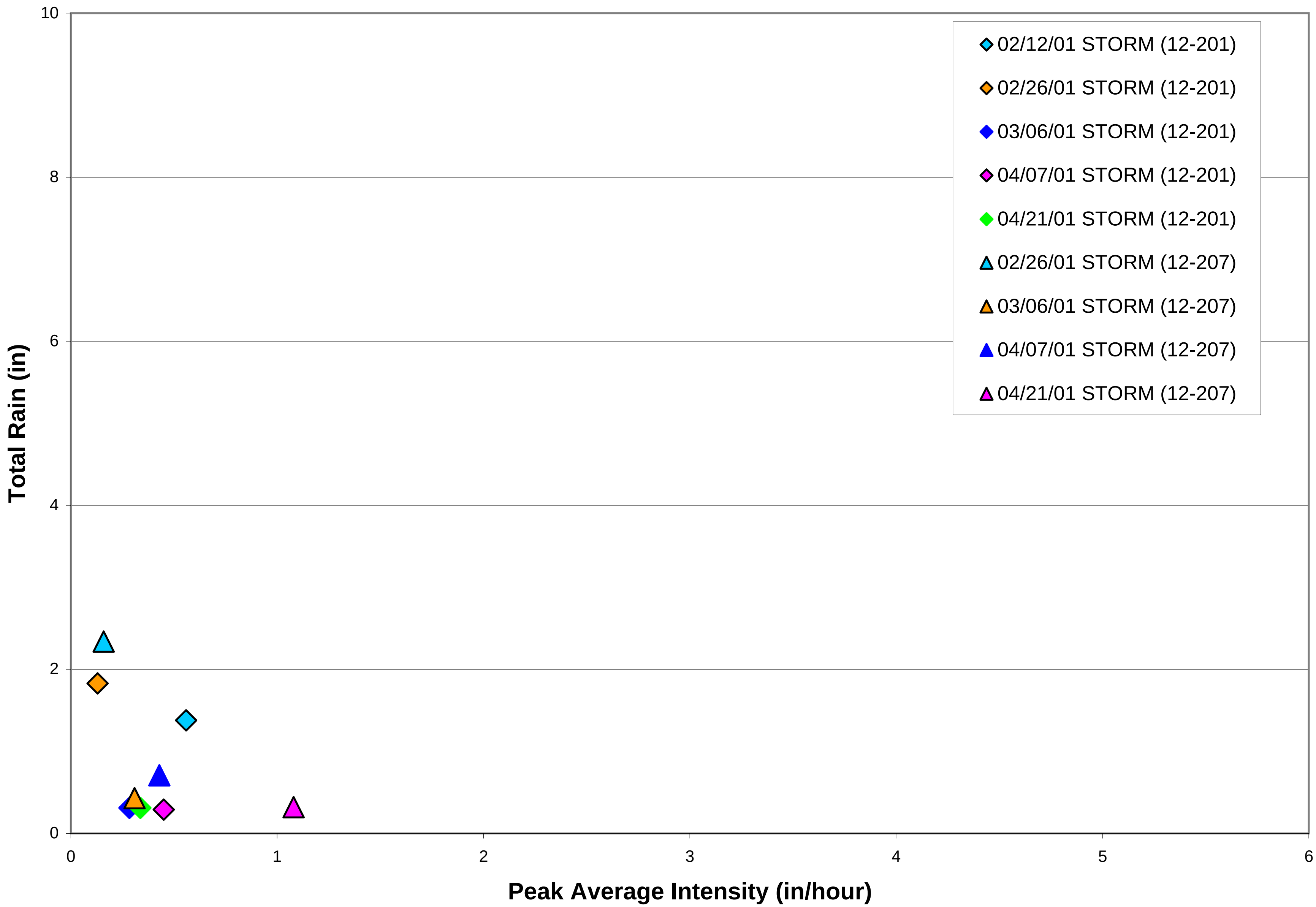
PRODUCT F (12-208)

Temporary Non-Vegetative Soil Stabilization Evaluation Study

Figure by	Project No.
AY	5865.003
Date	Figure
02/12/02	12

PRODUCT BEING APPLIED TO 12-209
(FEBRUARY 22, 2001)

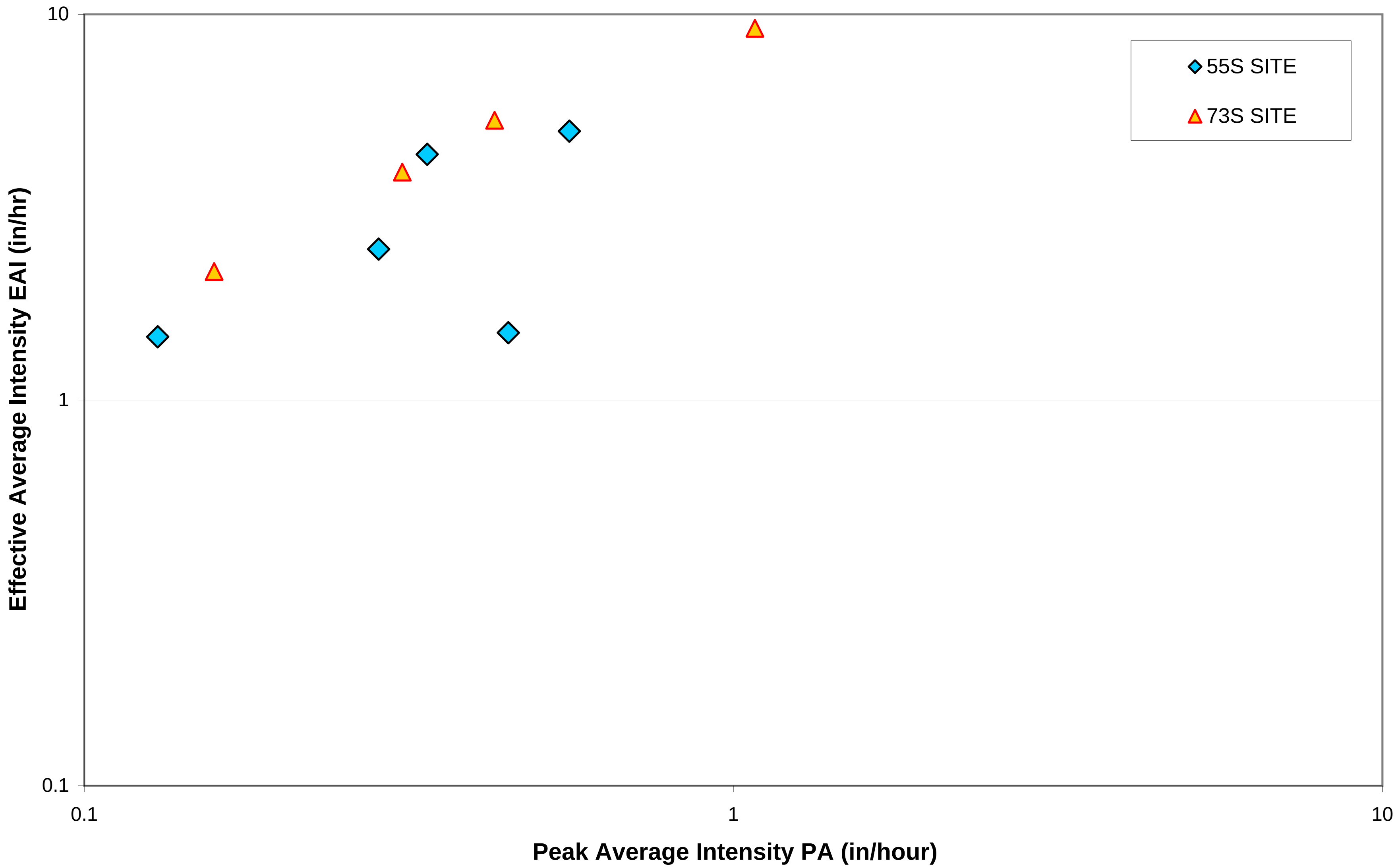
	PRODUCT G (12-209) PRODUCT APPLICATION Temporary Non-Vegetative Soil Stabilization Evaluation Study	Figure by AY	Project No. 5865.003
		Date 02/12/02	Figure 13



STORM CHARACTERISTICS

Temporary Non-Vegetative
Soil Stabilization Evaluation Study

Figure by pah	Project No. 5865.003
Date 02/12/02	Figure No. 14

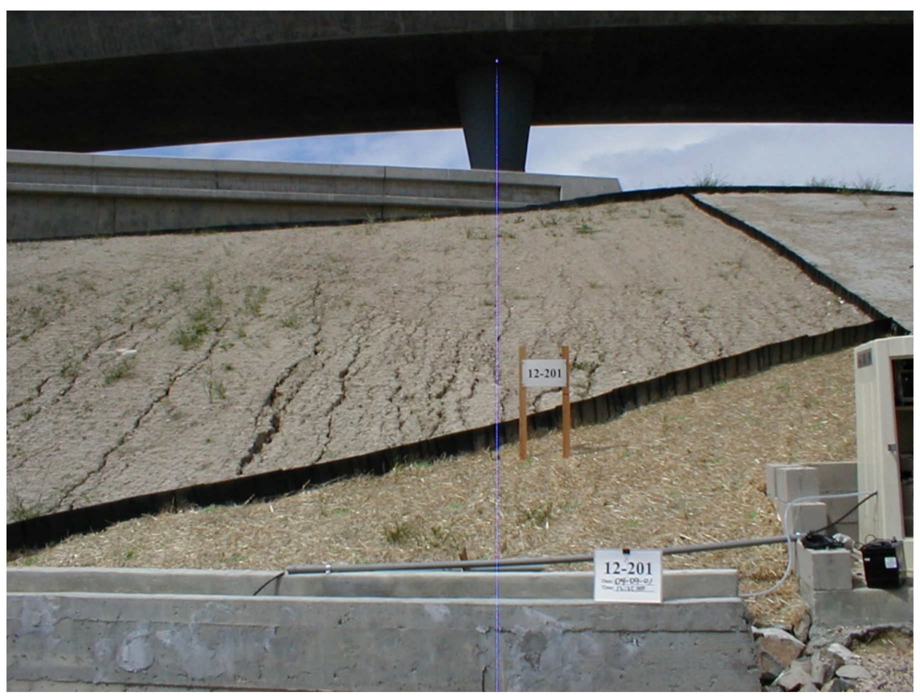


STORM INTENSITY Temporary Non-Vegetative Soil Stabilization Evaluation Study	Figure by pah Date 02/12/02	Project No. 5865.003 Figure No. 15

FEBRUARY 12, 2001

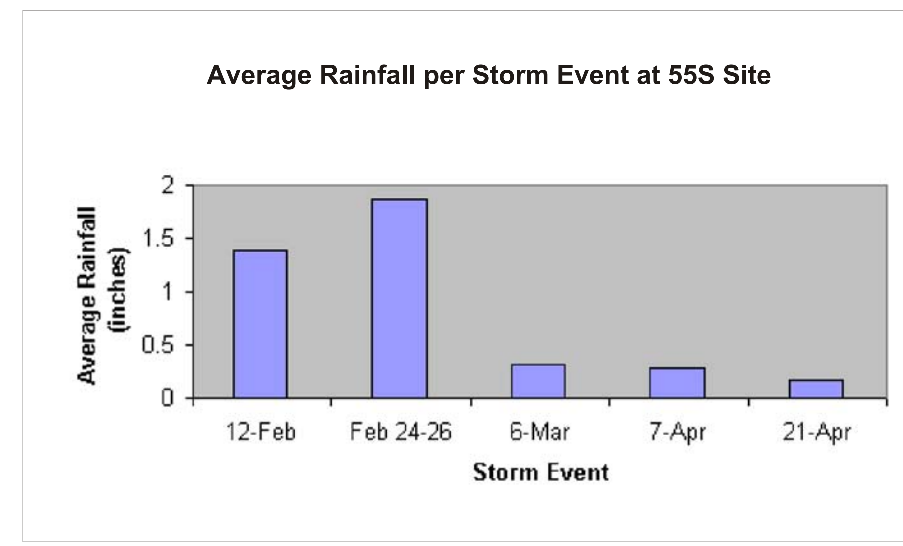
FEBRUARY 26, 2001

MARCH 12, 2001



APRIL 9, 2001

APRIL 25, 2001



BARE SLOPE (12-201)

TIME-SERIES SEQUENCE
Temporary Non-Vegetative
Soil Stabilization Evaluation Study

Figure by AY		Figure
Date 02/12/02	Project No. 5865.003	16

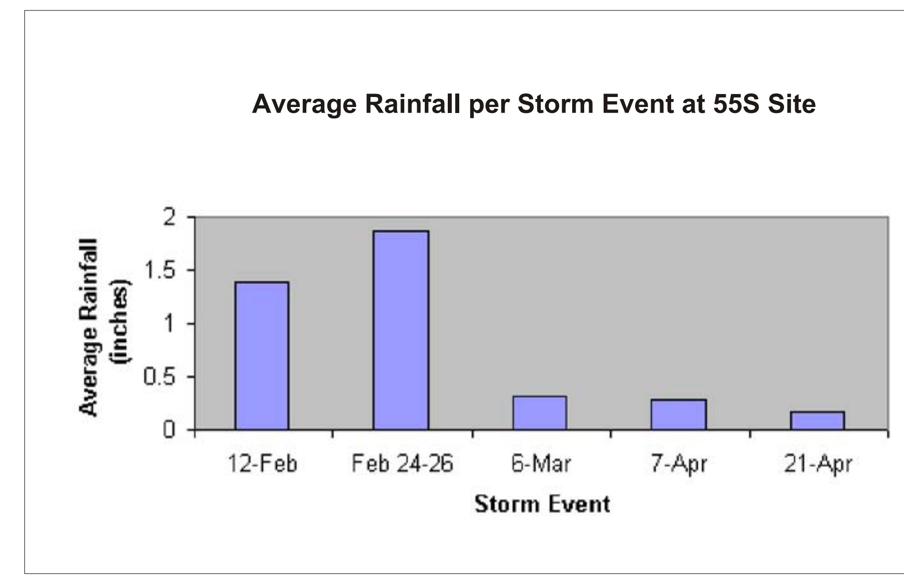
FEBRUARY 12, 2001

FEBRUARY 26, 2001

MARCH 12, 2001

APRIL 9, 2000

APRIL 25, 2001



PRODUCT A (12-202)
TIME-SERIES SEQUENCE
Temporary Non-Vegetative
Soil Stabilization Evaluation Study

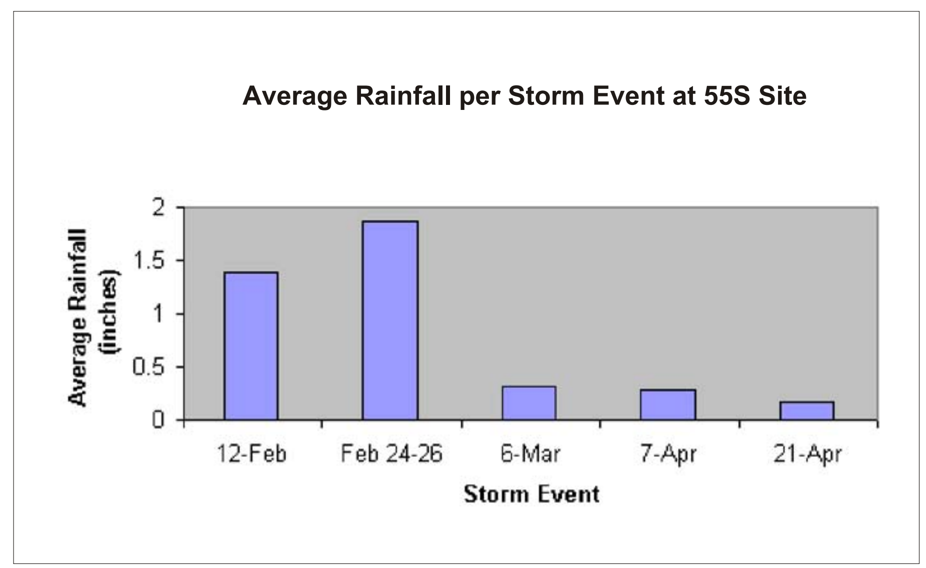
Figure by		Figure
AY		
Date 02/12/02	Project No. 5865.003	17

FEBRUARY 26, 2001

MARCH 12, 2001

APRIL 9, 2001

APRIL 25, 2001



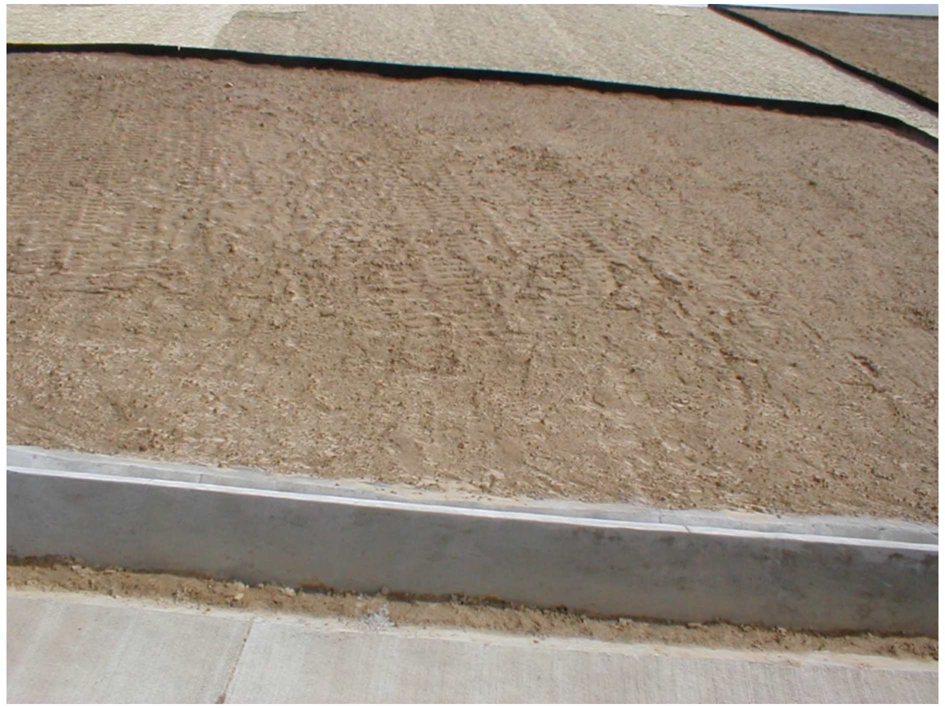
PRODUCT B (12-203)

TIME-SERIES SEQUENCE

Temporary Non-Vegetative

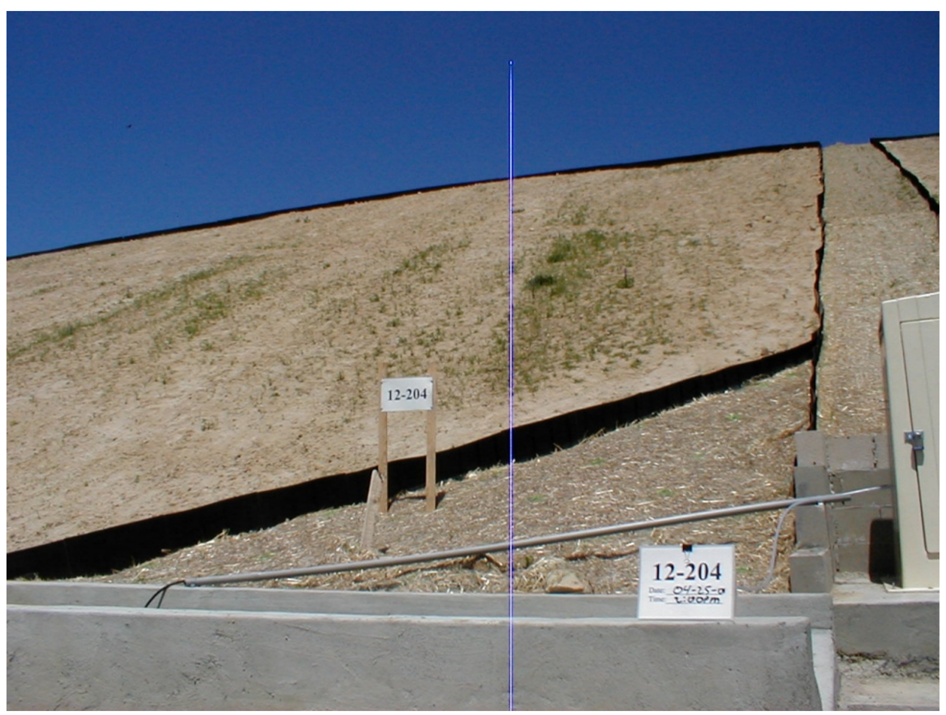
Soil Stabilization Evaluation Study

Figure by AY		Figure
Date 02/12/02	Project No. 5865.003	18



MARCH 7, 2001

APRIL 9, 2001



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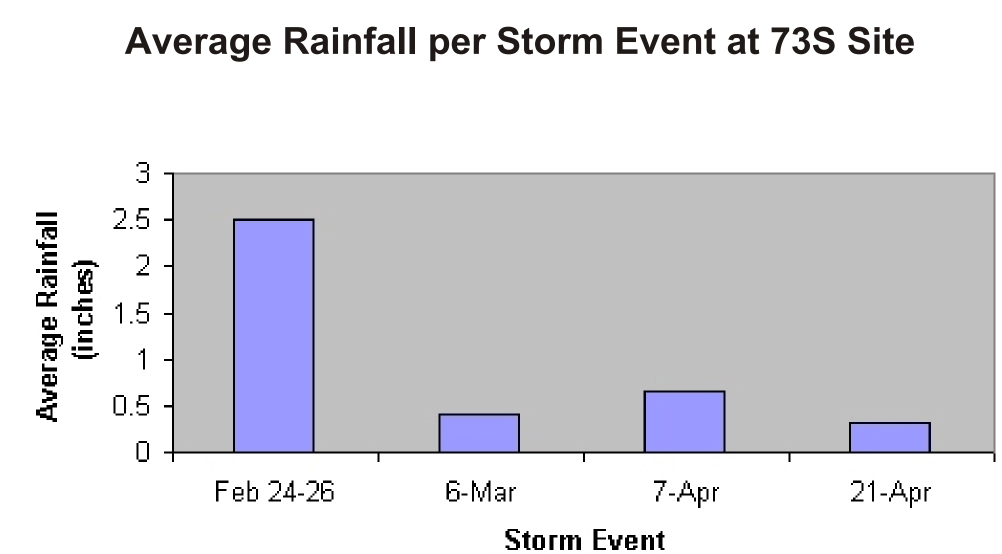

BARE SLOPE (12-204)
TIME-SERIES SEQUENCE
Temporary Non-Vegetative
Soil Stabilization Evaluation Study

Figure by		Figure
AY		
Date	Project No.	19
02/12/02	5865.003	

MARCH 7, 2001

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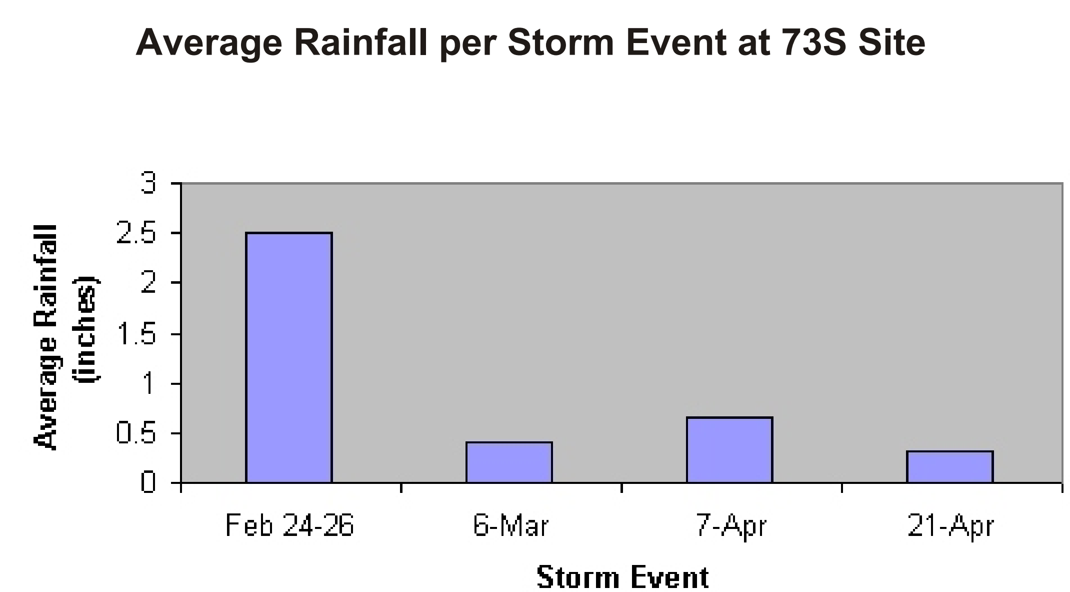

PRODUCT C (12-205)
TIME-SERIES SEQUENCE
Temporary Non-Vegetative
Soil Stabilization Evaluation Study

Figure by		Figure
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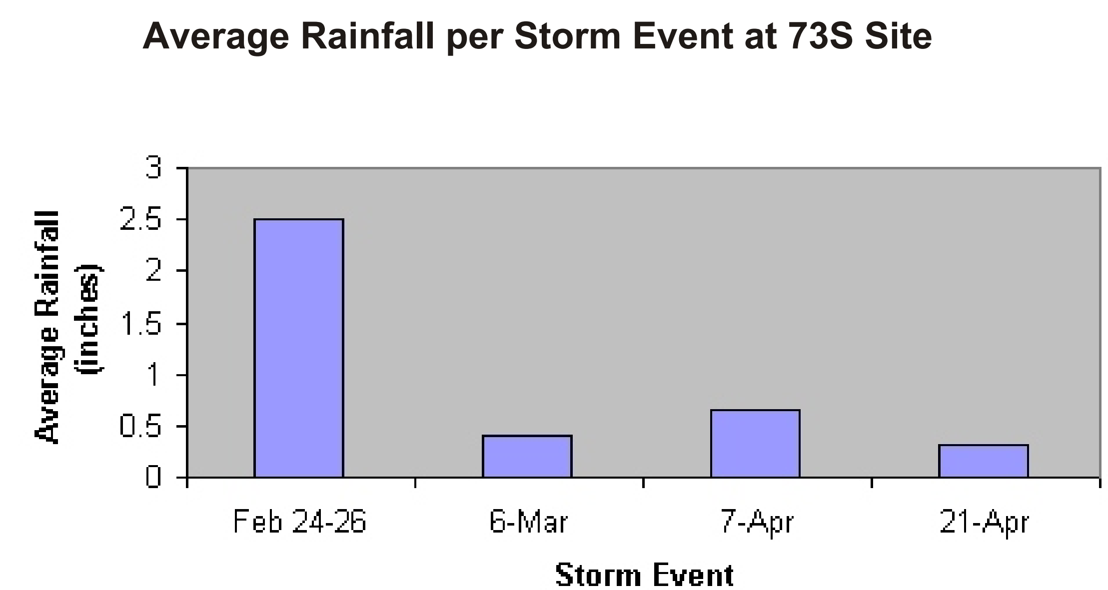
Date	Project No.	20
02/12/02	5865.003	

MARCH 7, 2001

APRIL 9, 2001

APRIL 25, 2001



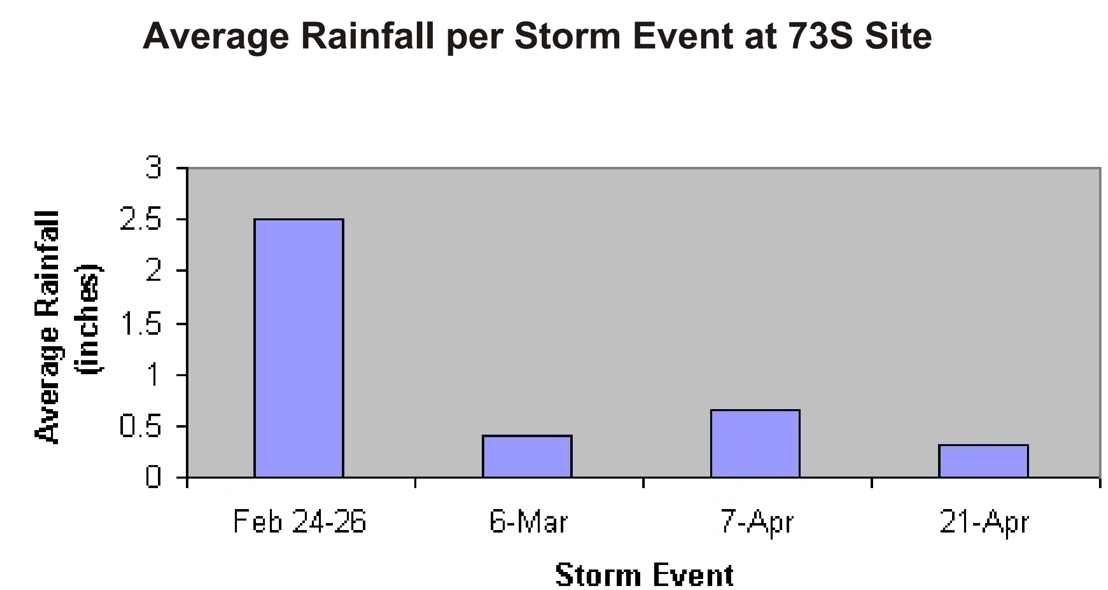
PRODUCT D (12-206)
TIME-SERIES SEQUENCE
Temporary Non-Vegetative
Soil Stabilization Evaluation Study

Figure by AY		Figure
Date 02/12/02	Project No. 5865.003	21

MARCH 7, 2001

APRIL 9, 2001

APRIL 25, 2001



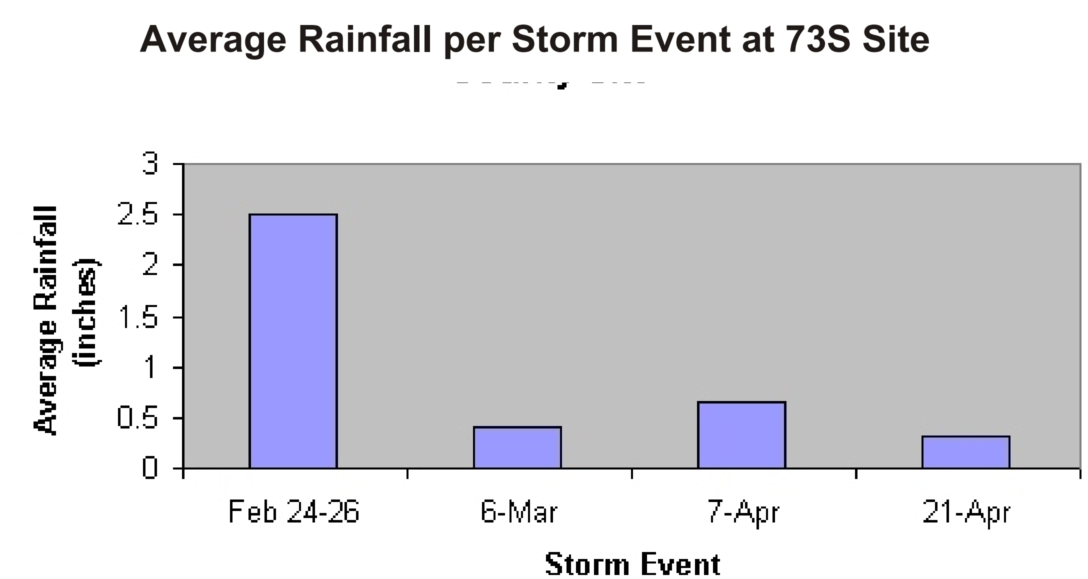
PRODUCT D (12-206)
TIME-SERIES SEQUENCE
Temporary Non-Vegetative
Soil Stabilization Evaluation Study

Figure by		Figure
AY		
Date	Project No.	
02/12/02	5865.003	21

MARCH 7, 2001

APRIL 9, 2001

APRIL 25, 2001



PRODUCT E (12-207)

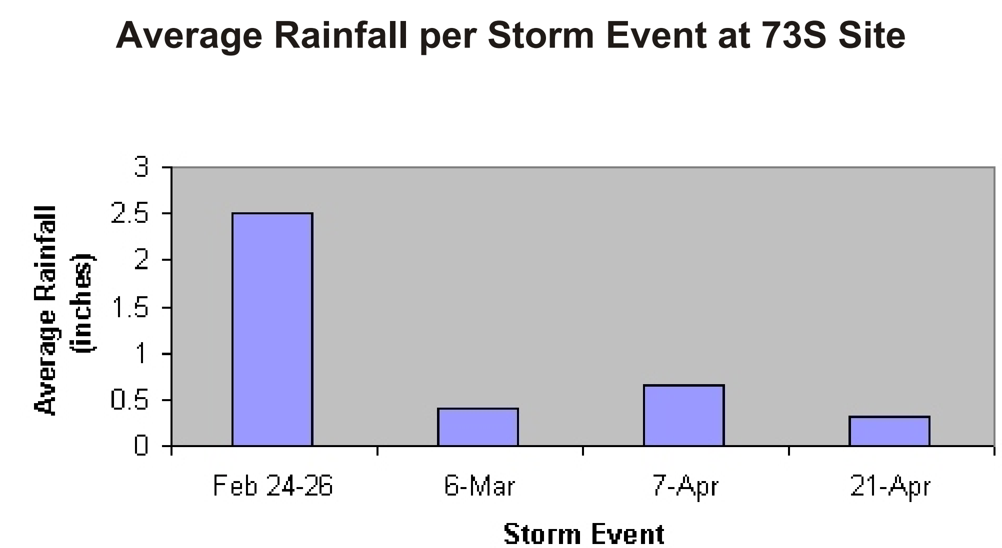
TIME-SERIES SEQUENCE
Temporary Non-Vegetative
Soil Stabilization Evaluation Study

Figure by		Figure
AY		
Date	Project No.	
02/12/02	5865.003	22

MARCH 7, 2001

APRIL 9, 2001

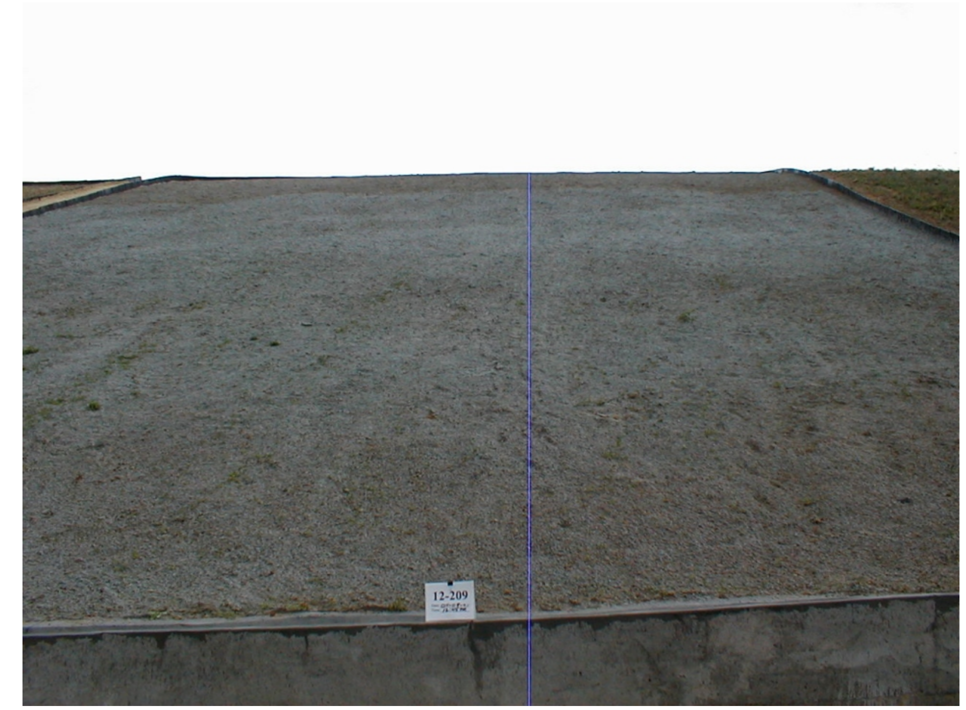
APRIL 25, 2001



PRODUCT F (12-208)
TIME-SERIES SEQUENCE
Temporary Non-Vegetative
Soil Stabilization Evaluation Study

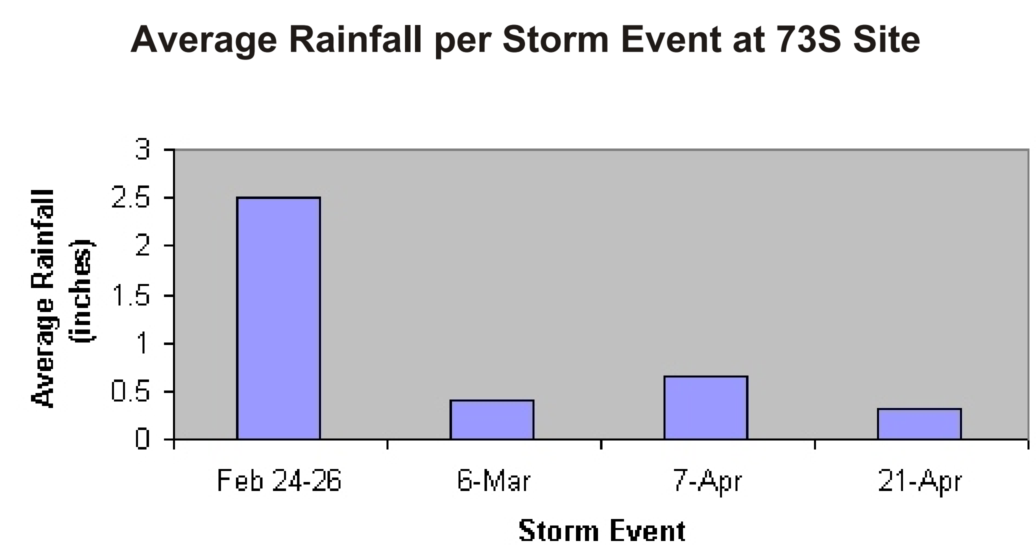
Figure by		Figure
AY		
Date 02/12/02	Project No. 5865.003	23

MARCH 7, 2001



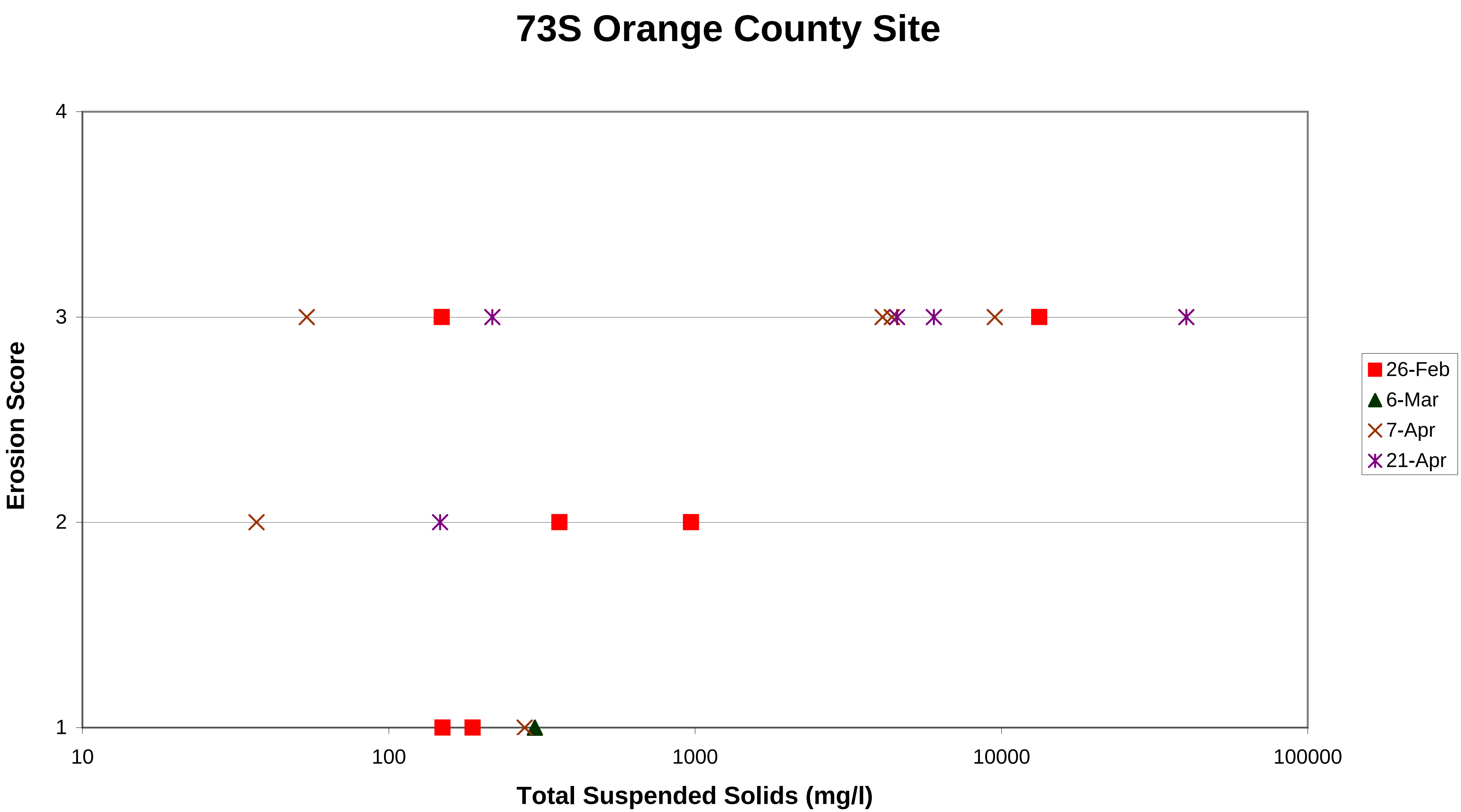
APRIL 9, 2001

APRIL 25, 2001



PRODUCT G (12-209)
TIME-SERIES SEQUENCE
Temporary Non-Vegetative
Soil Stabilization Evaluation Study

Figure by AY		Figure
Date 02/12/02	Project No. 5865.003	24



NOTE: SEE SECTION 6.1 OF REPORT FOR DISCUSSION OF EROSION SCORE.

TOTAL SUSPENDED SOLIDS AND EROSION PERFORMANCE

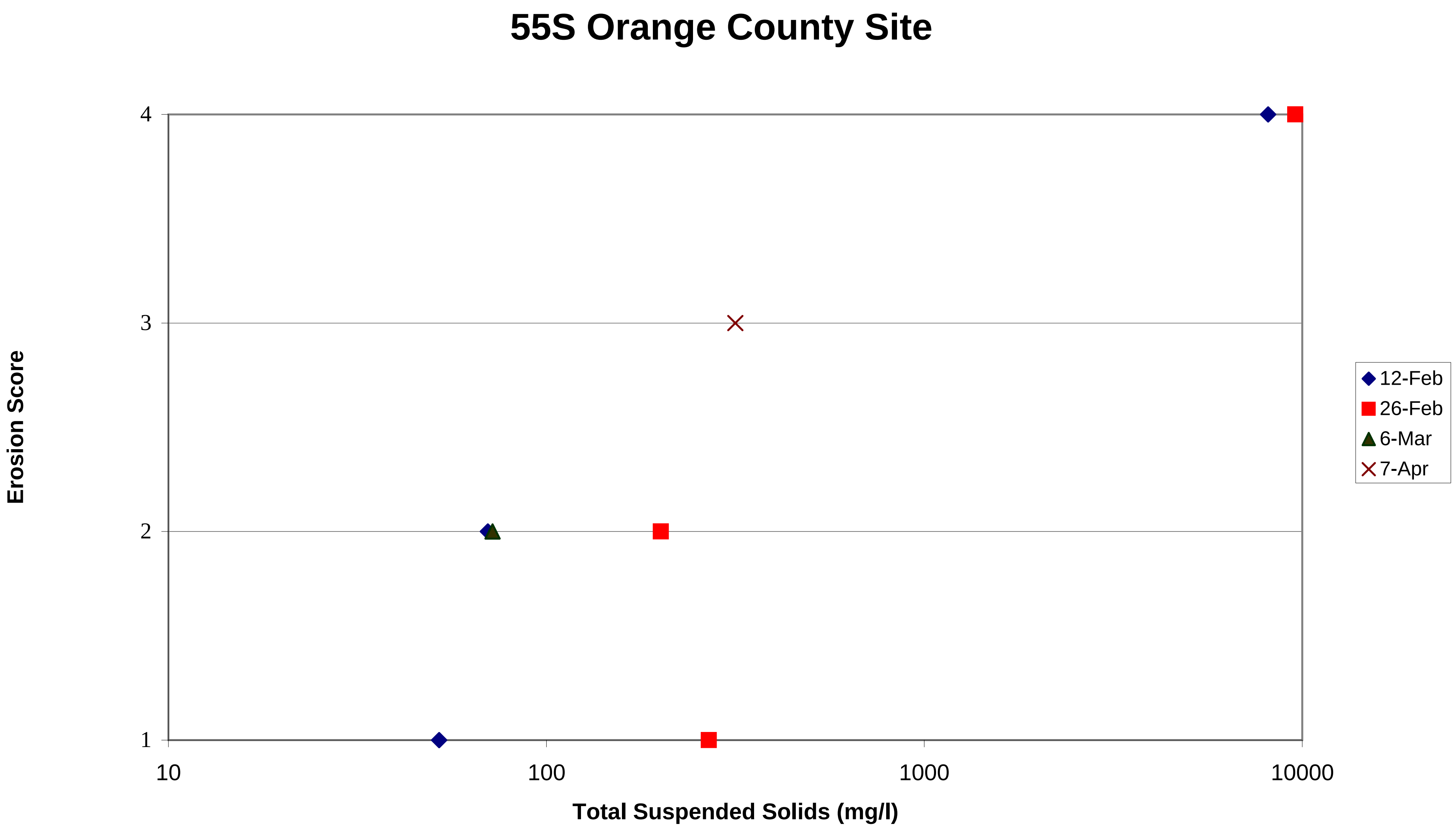
Temporary Non-Vegetative
Soil Stabilization Evaluation Study

Figure by PAH

Date 02/12/02

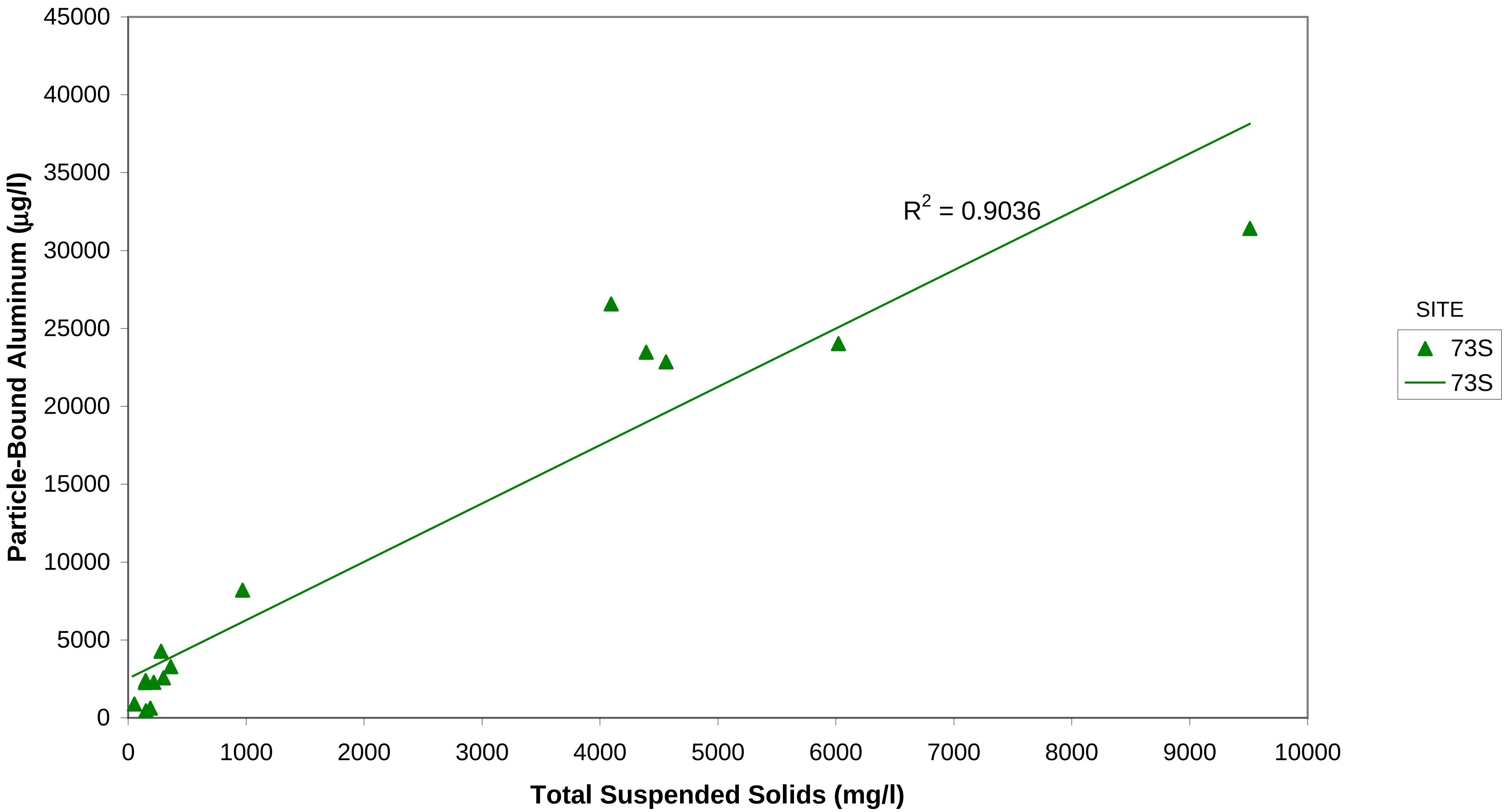
Project No. 5865.003

Figure No. 25

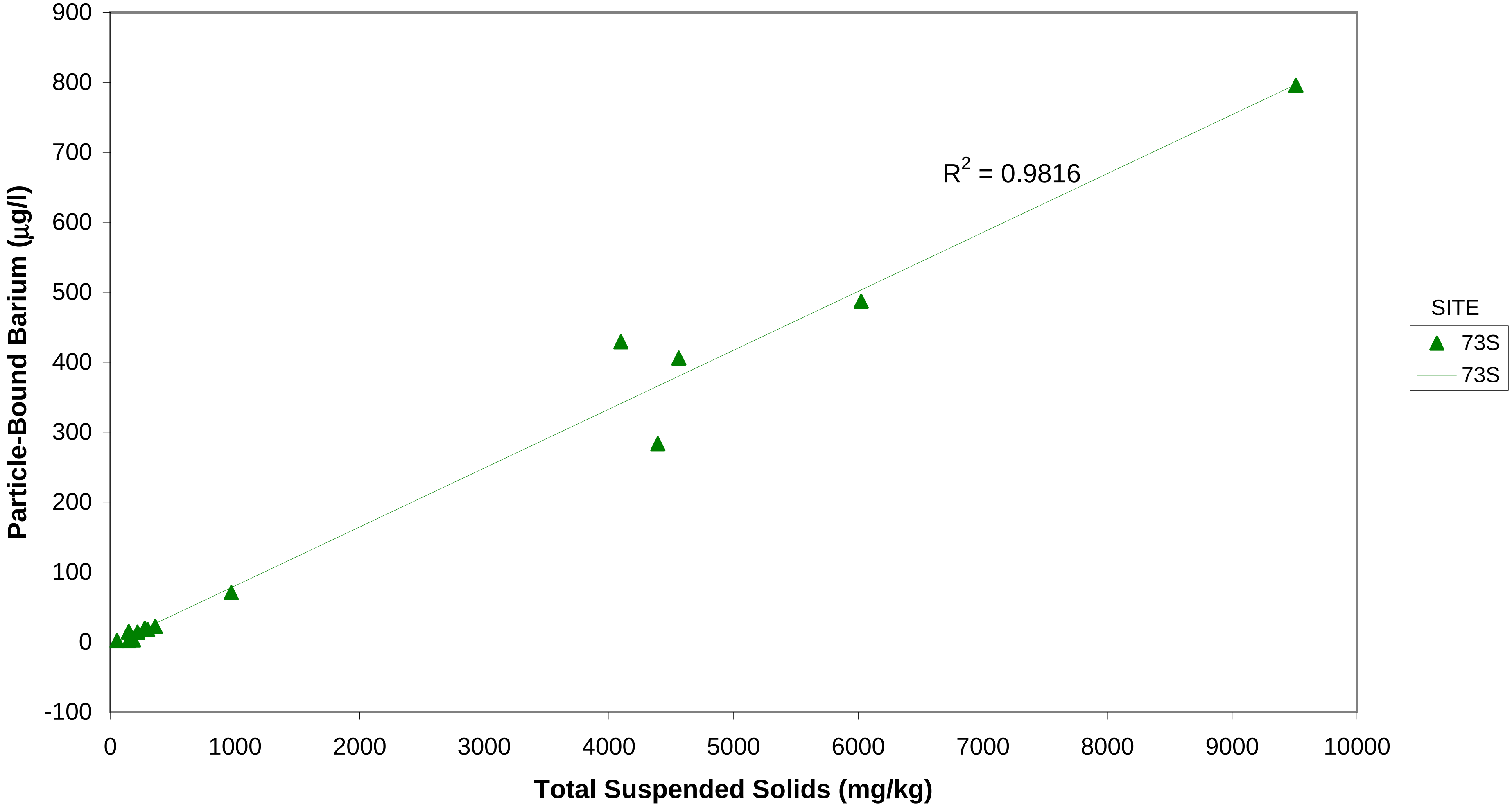


NOTE: SEE SECTION 6.1 OF REPORT FOR DISCUSSION OF EROSION SCORE.
NO SAMPLES COLLECTED AT 55S SITE DURING APRIL 21, 2001 STORM

TOTAL SUSPENDED SOLIDS AND EROSION PERFORMANCE Temporary Non-Vegetative Soil Stabilization Evaluation Study	Figure by PAH Date 02/12/02	Project No. 5865.003 Figure No. 26



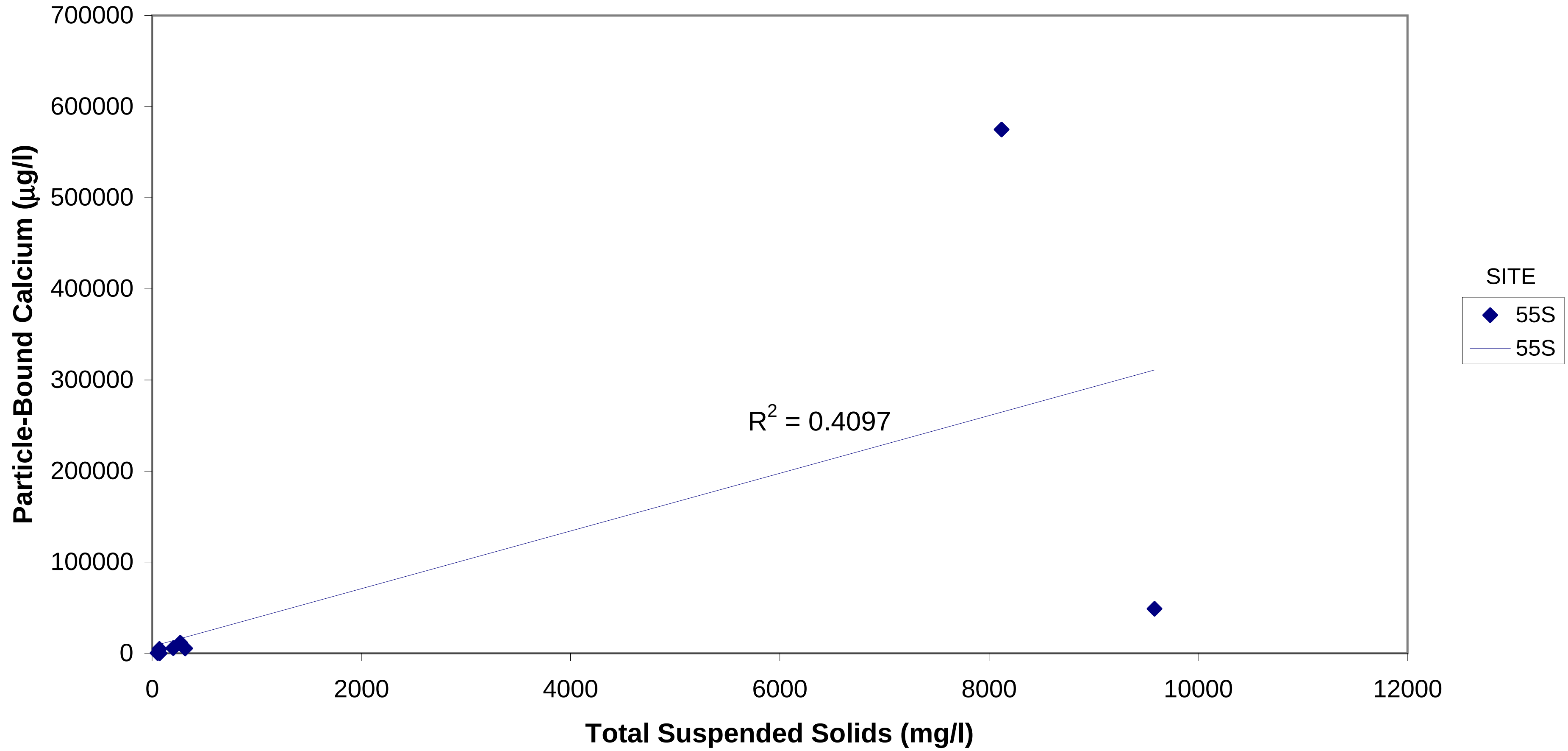
PARTICLE-BOUND ALUMINUM vs. TOTAL SUSPENDED SOLIDS	Figure by ay	Project No. 5865.003
Temporary Non-Vegetative Soil Stabilization Evaluation Study	Date 02/12/02	Figure No. 27



PARTICLE-BOUND BARIUM vs. TOTAL SUSPENDED SOLIDS

Temporary Non-Vegetative
Soil Stabilization Evaluation Study

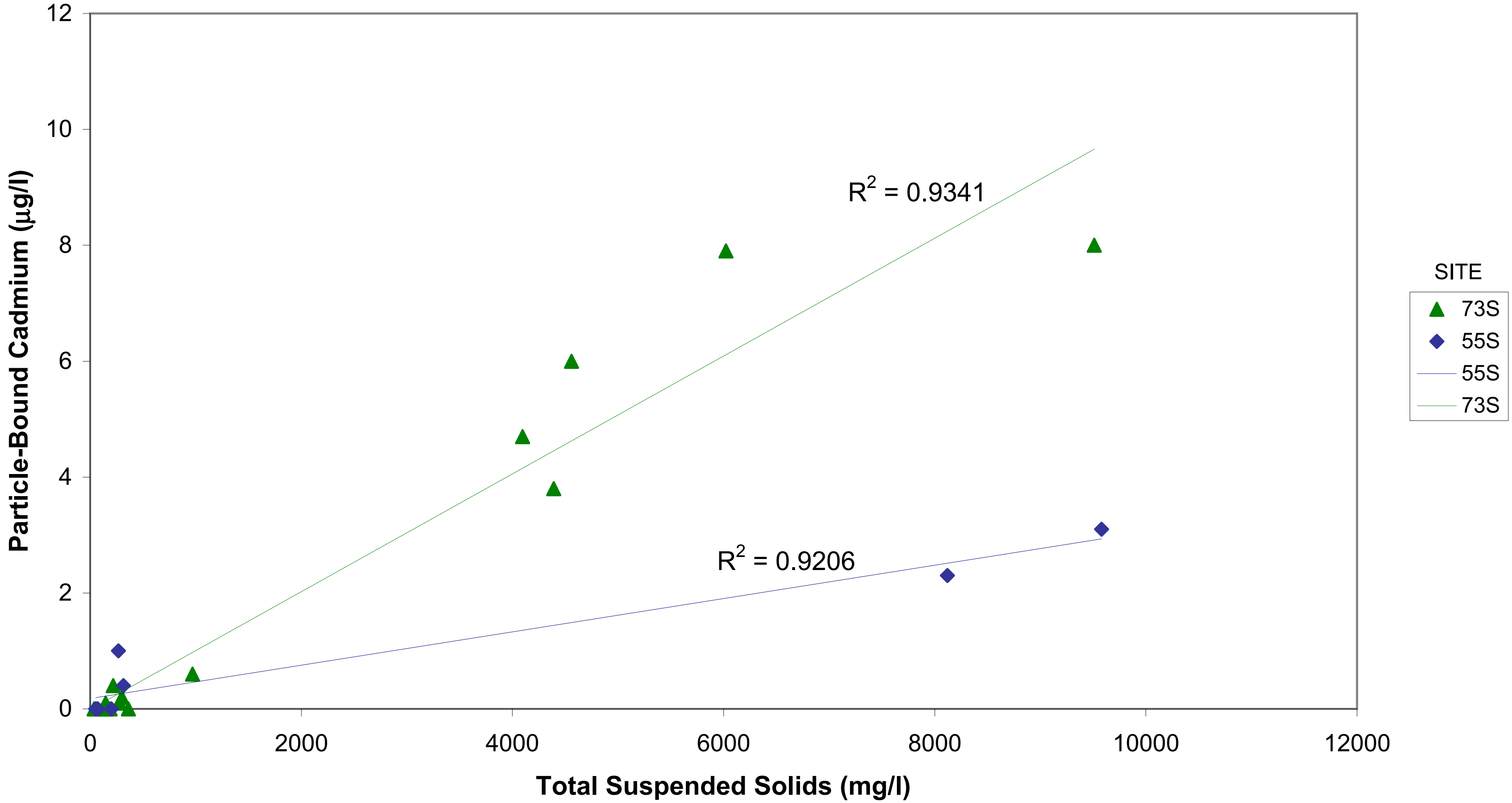
Figure by ay	Project No. 5865.003
Date 02/12/02	Figure No. 28



PARTICLE-BOUND CALCIUM vs. TOTAL SUSPENDED SOLIDS

Temporary Non-Vegetative
Soil Stabilization Evaluation Study

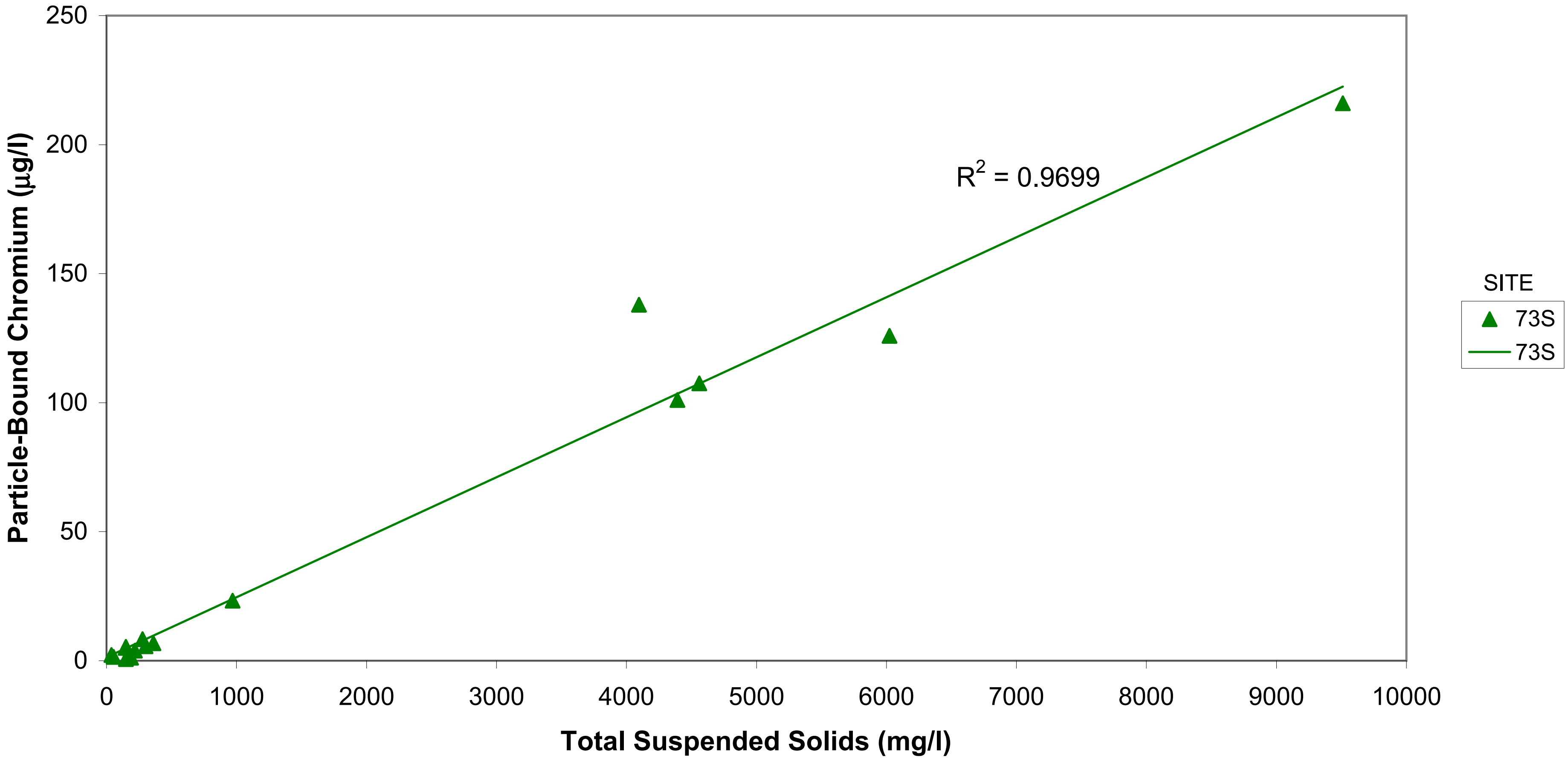
Figure by ay	Project No. 5865.003
Date 02/12/02	Figure No. 29



PARTICLE-BOUND CADMIUM vs. TOTAL SUSPENDED SOLIDS

Temporary Non-Vegetative
Soil Stabilization Evaluation Study

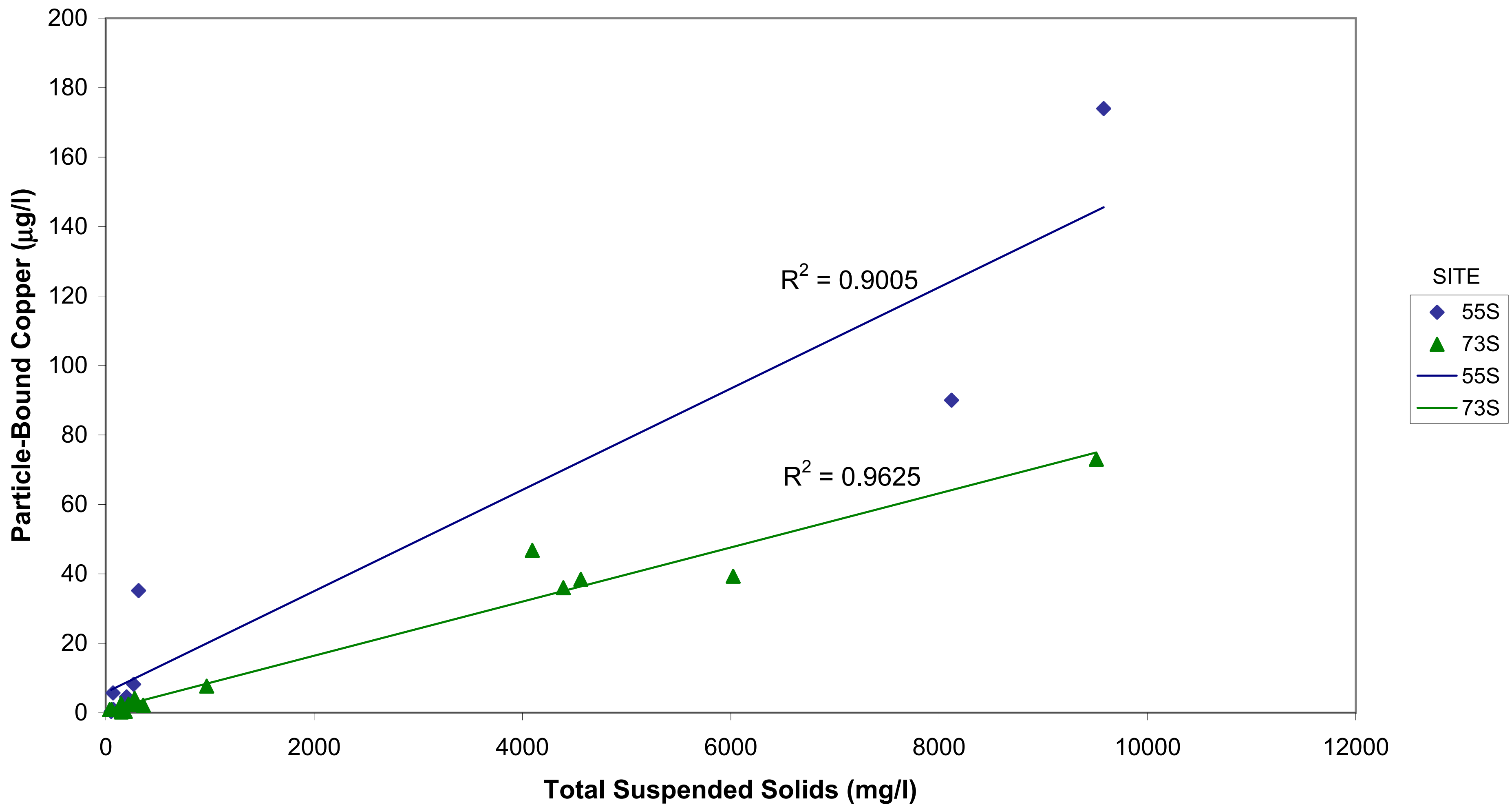
Figure by	Project No.
ay	5865.003
Date	Figure No.
02/12/02	30



PARTICLE-BOUND CHROMIUM vs. TOTAL SUSPENDED SOLIDS

Temporary Non-Vegetative
Soil Stabilization Evaluation Study

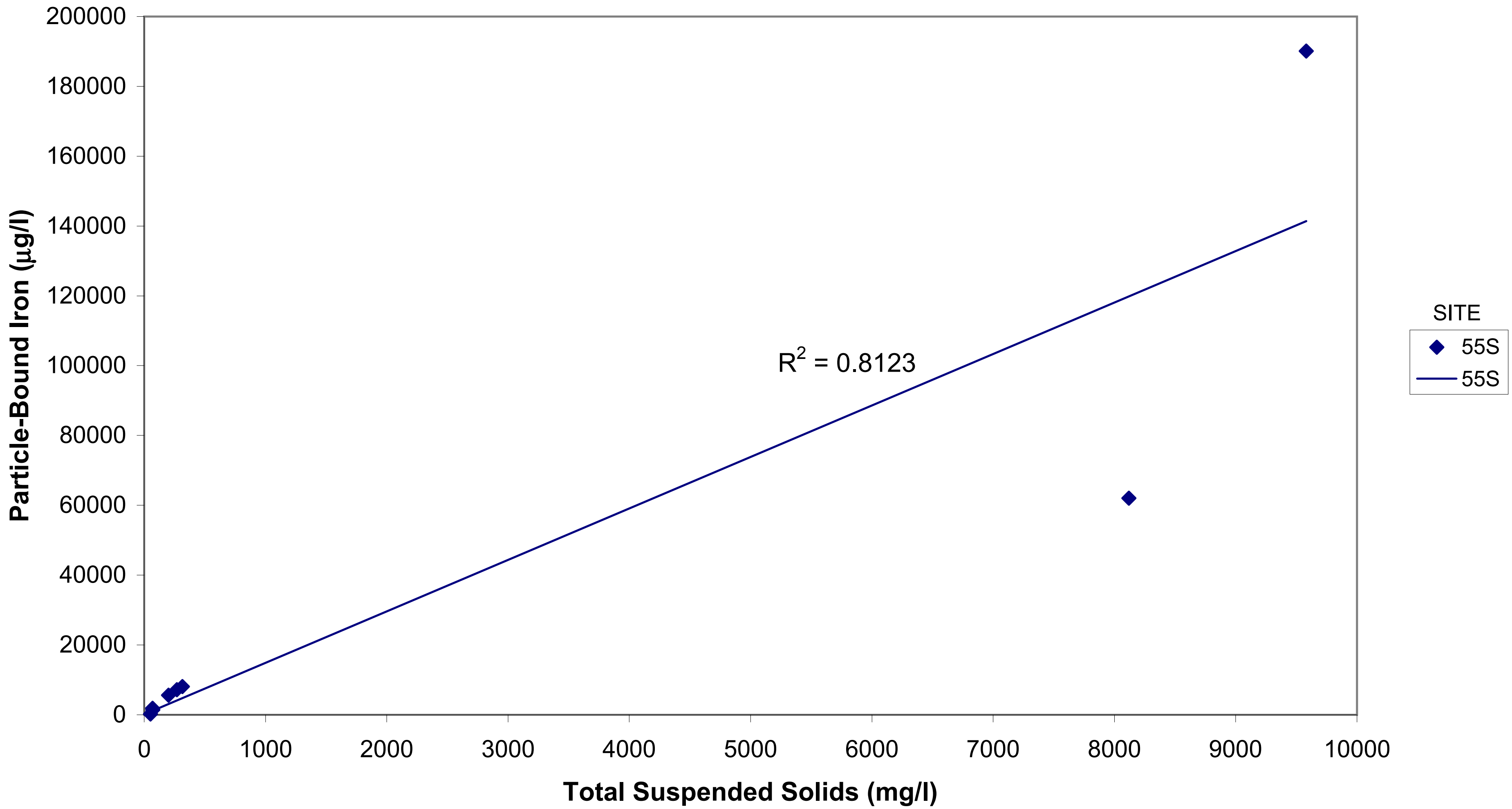
Figure by ay	Project No. 5865.003
Date 02/12/02	Figure No. 31



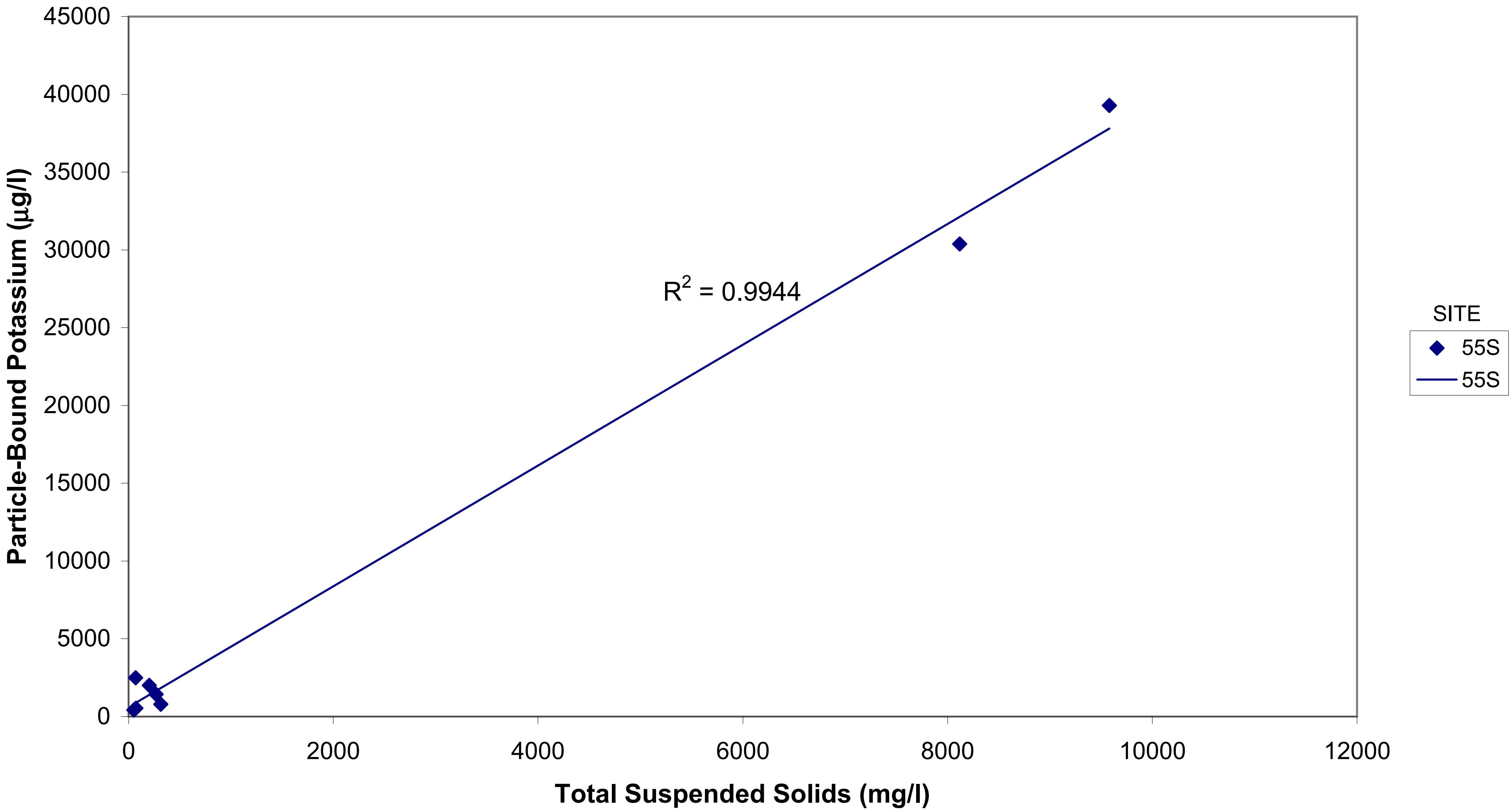
PARTICLE-BOUND COPPER vs. TOTAL SUSPENDED SOLIDS

Temporary Non-Vegetative
Soil Stabilization Evaluation Study

Figure by ay	Project No. 5865.003
Date 02/12/02	Figure No. 32



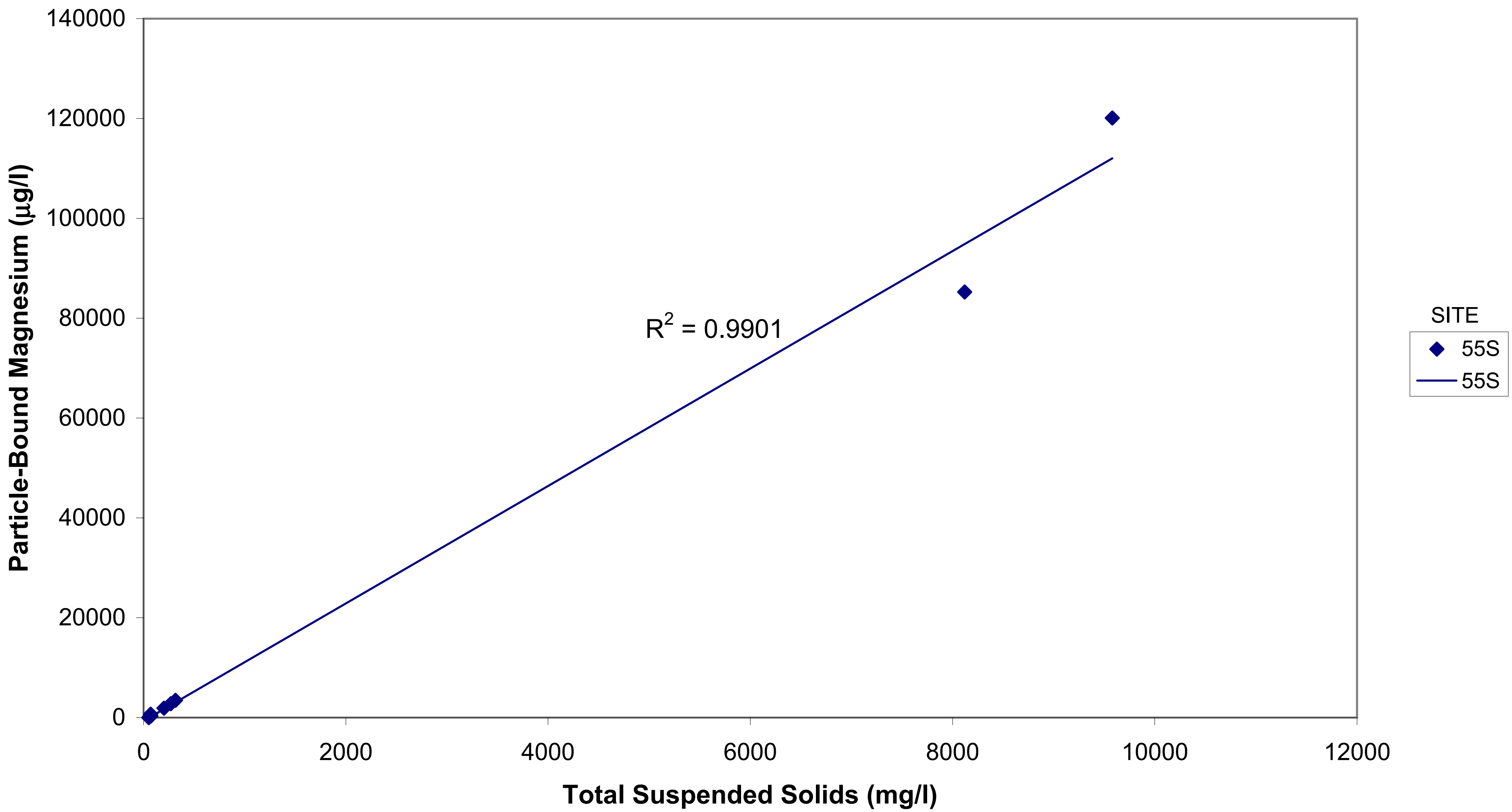
PARTICLE-BOUND IRON vs. TOTAL SUSPENDED SOLIDS Temporary Non-Vegetative Soil Stabilization Evaluation Study	Figure by ay Date 02/12/02	Project No. 5865.003 Figure No. 33



PARTICLE-BOUND POTASSIUM vs. TOTAL SUSPENDED SOLIDS

Temporary Non-Vegetative
Soil Stabilization Evaluation Study

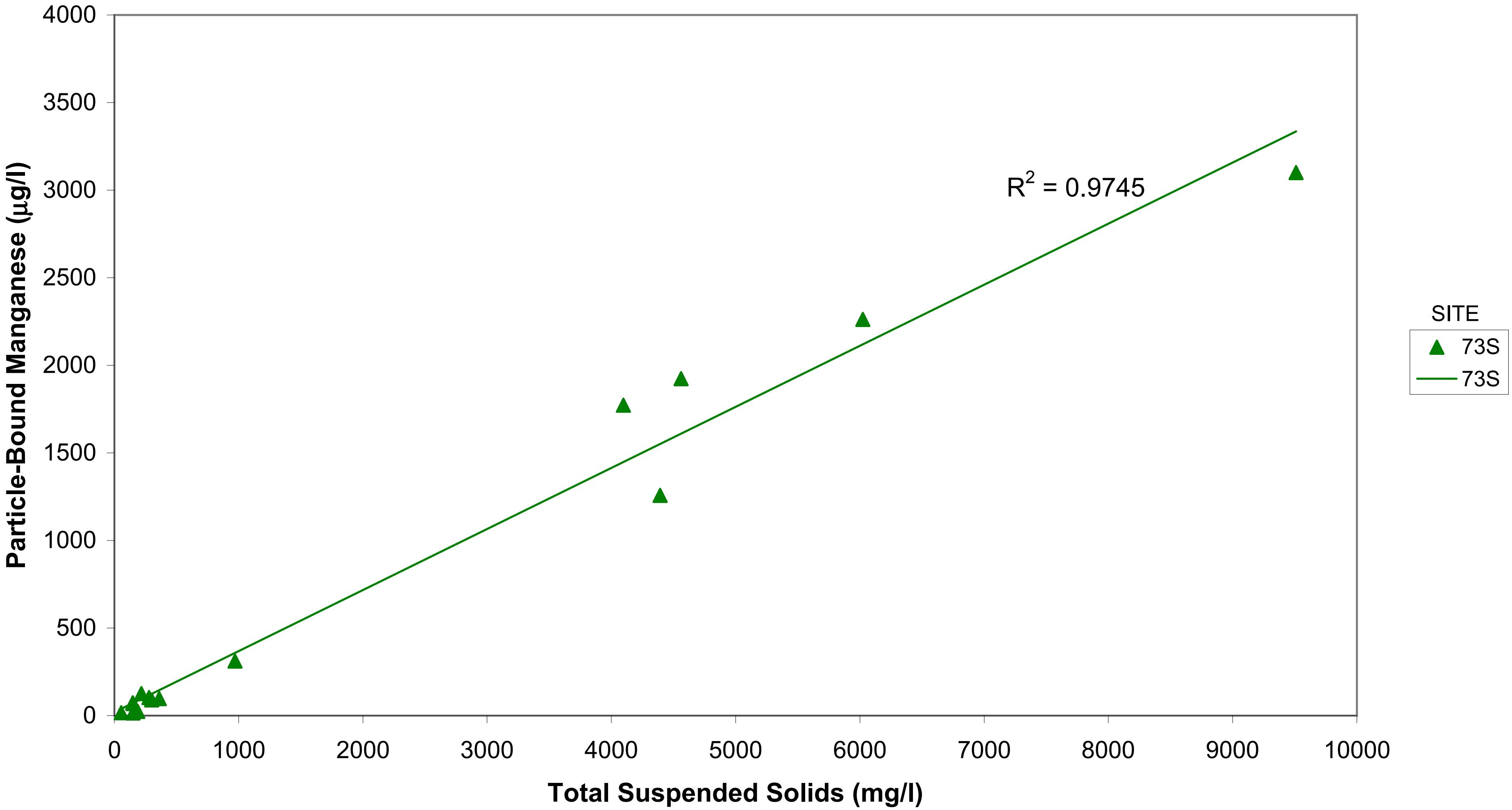
Figure by ay	Project No. 5865.003
Date 02/12/02	Figure No. 34



PARTICLE-BOUND MAGNESIUM vs. TOTAL SUSPENDED SOLIDS

Temporary Non-Vegetative
Soil Stabilization Evaluation Study

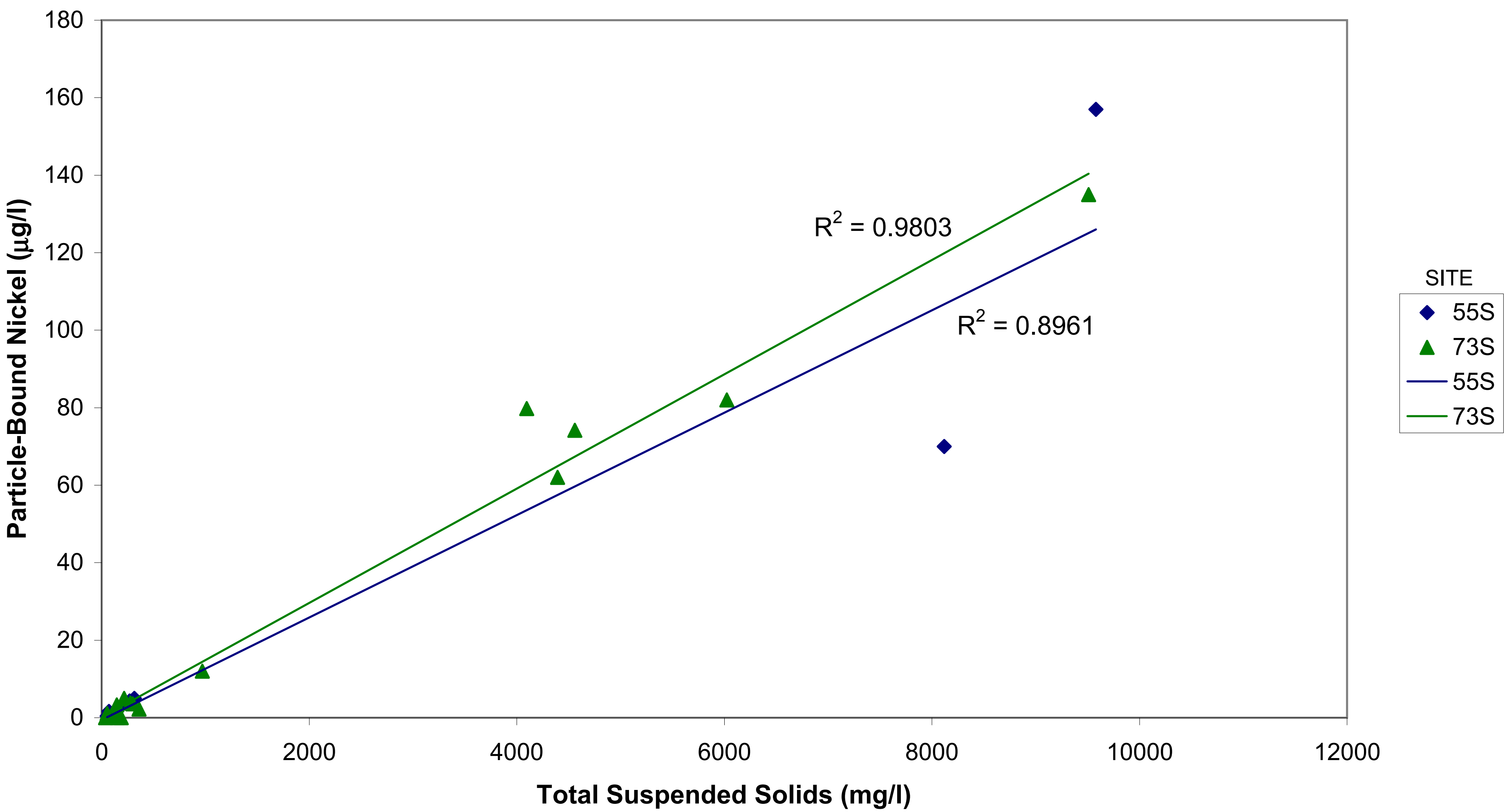
Figure by ay	Project No. 5865.003
Date 02/12/02	Figure No. 35



PARTICLE-BOUND MANGANESE vs. TOTAL SUSPENDED SOLIDS

Temporary Non-Vegetative
Soil Stabilization Evaluation Study

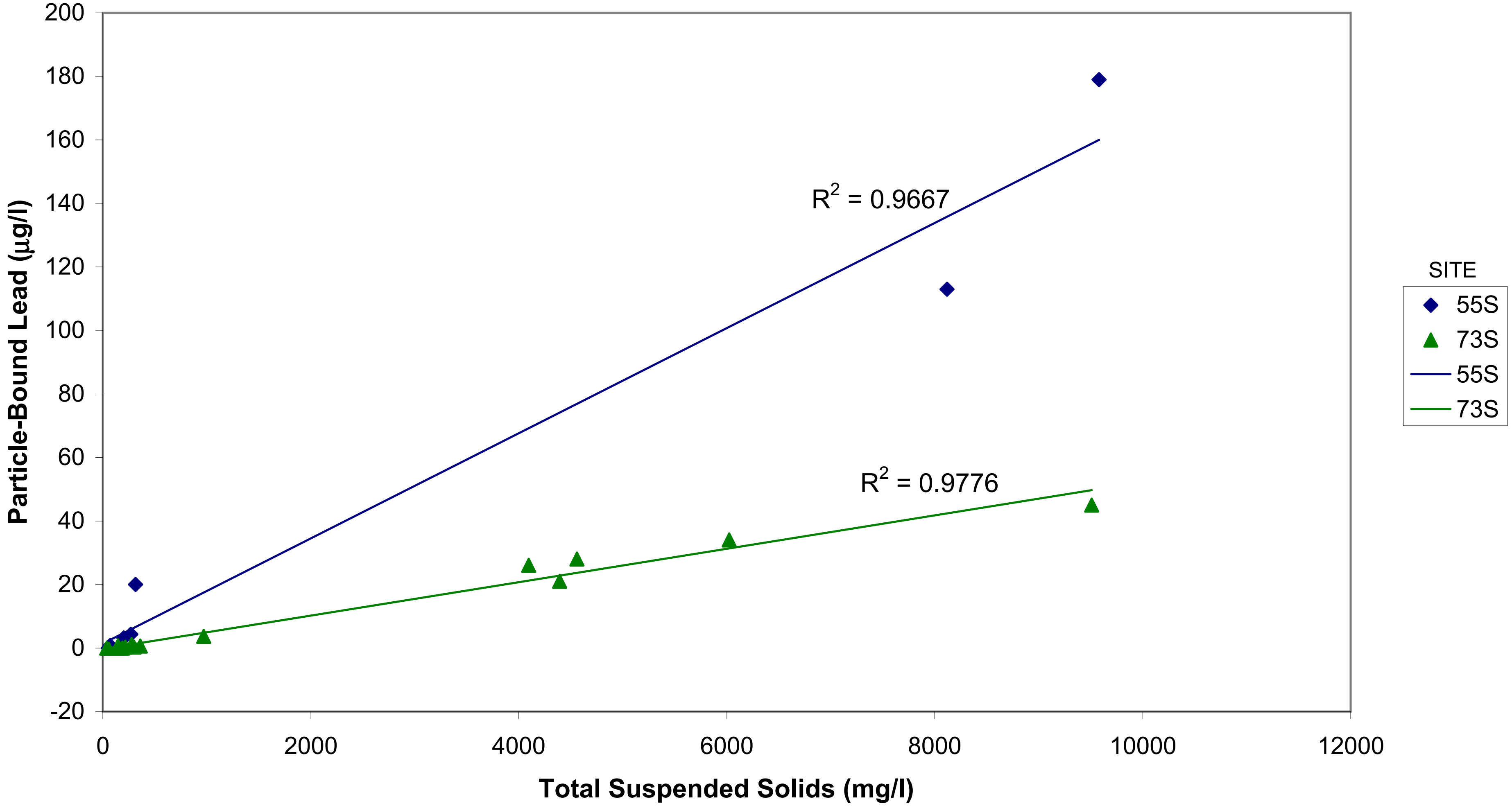
Figure by ay	Project No. 5865.003
Date 02/12/02	Figure No. 36



PARTICLE-BOUND NICKEL vs. TOTAL SUSPENDED SOLIDS

Temporary Non-Vegetative
Soil Stabilization Evaluation Study

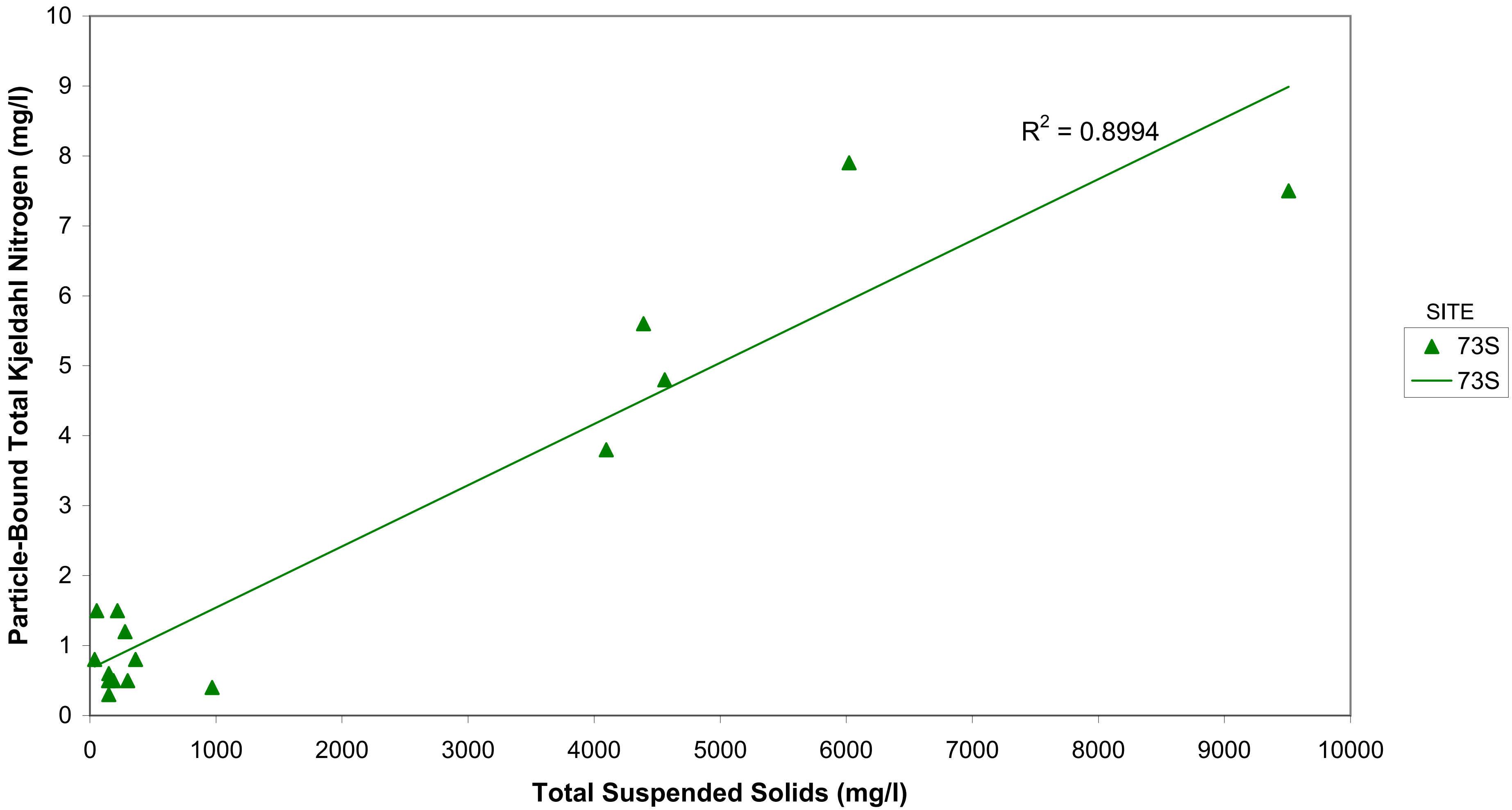
Figure by ay	Project No. 5865.003
Date 02/12/02	Figure No. 37



PARTICLE-BOUND LEAD vs. TOTAL SUSPENDED SOLIDS

Temporary Non-Vegetative
Soil Stabilization Evaluation Study

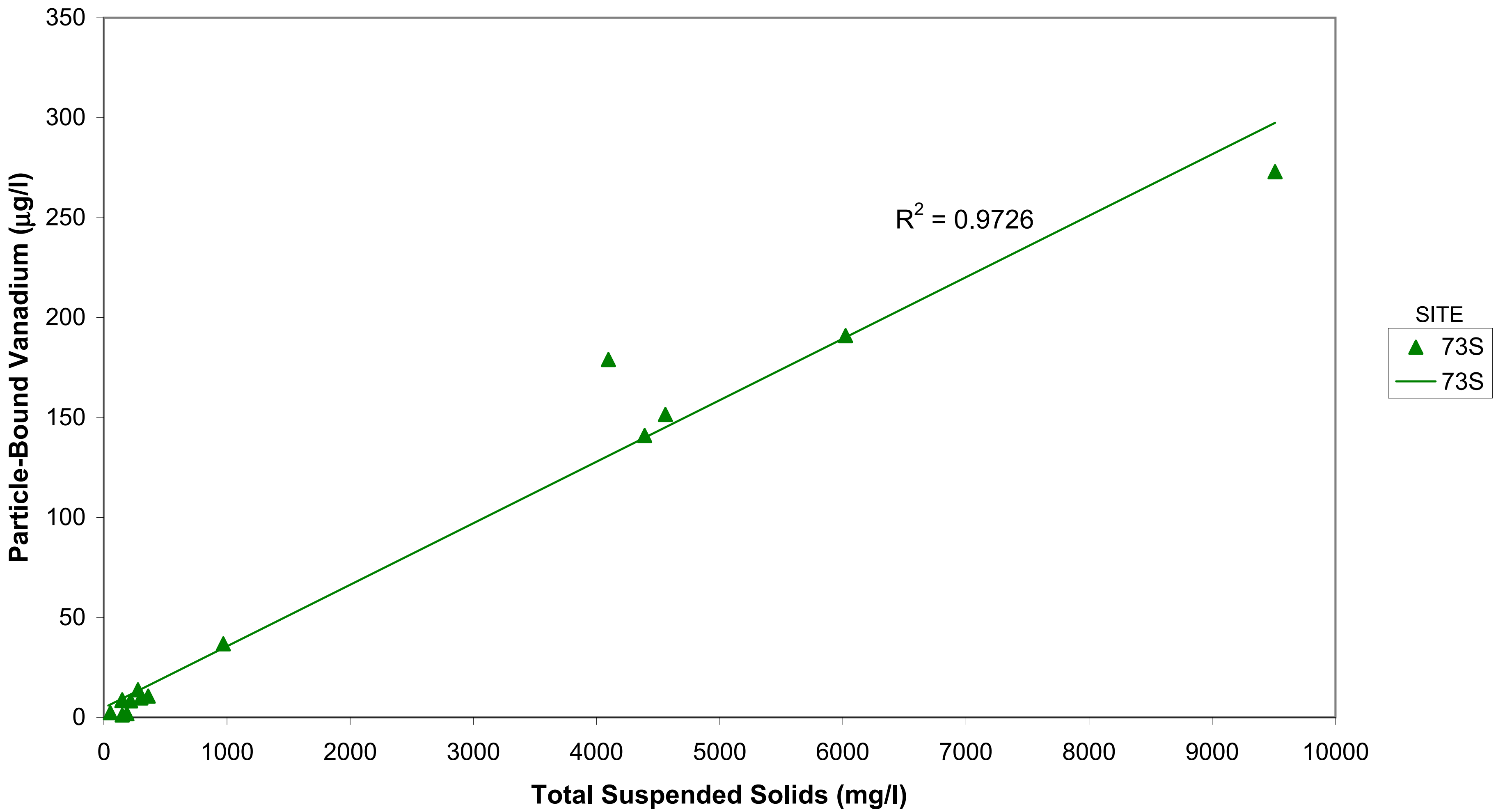
Figure by ay	Project No. 5865.003
Date 02/12/02	Figure No. 38



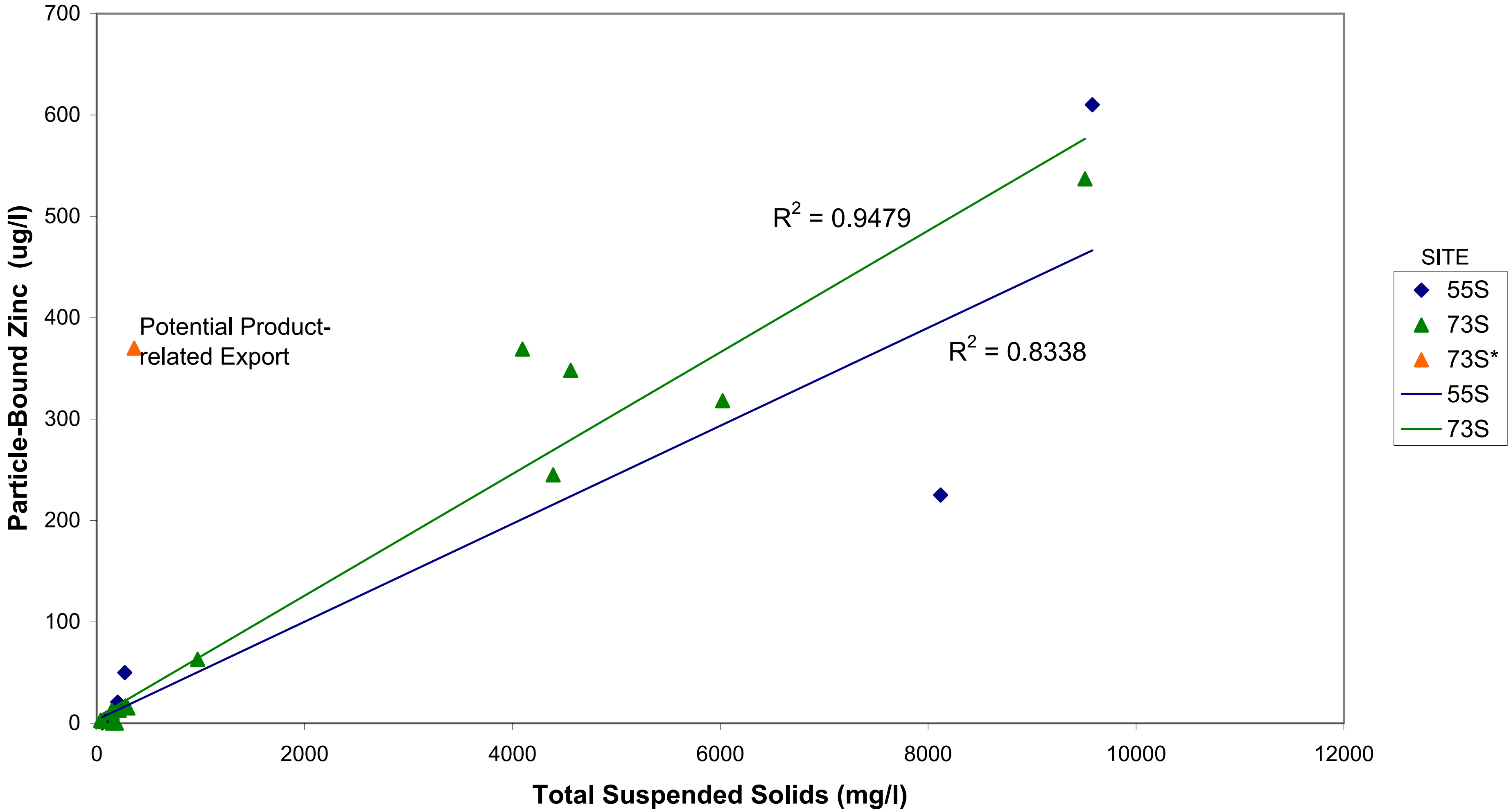
PARTICLE-BOUND TOTAL KJELDAHL NITROGEN vs. TOTAL SUSPENDED SOLIDS

Temporary Non-Vegetative
Soil Stabilization Evaluation Study

Figure by ay	Project No. 5865.003
Date 02/12/02	Figure No. 39



PARTICLE-BOUND VANADIUM vs. TOTAL SUSPENDED SOLIDS Temporary Non-Vegetative Soil Stabilization Evaluation Study	Figure by ay Date 02/12/02	Project No. 5865.003 Figure No. 40

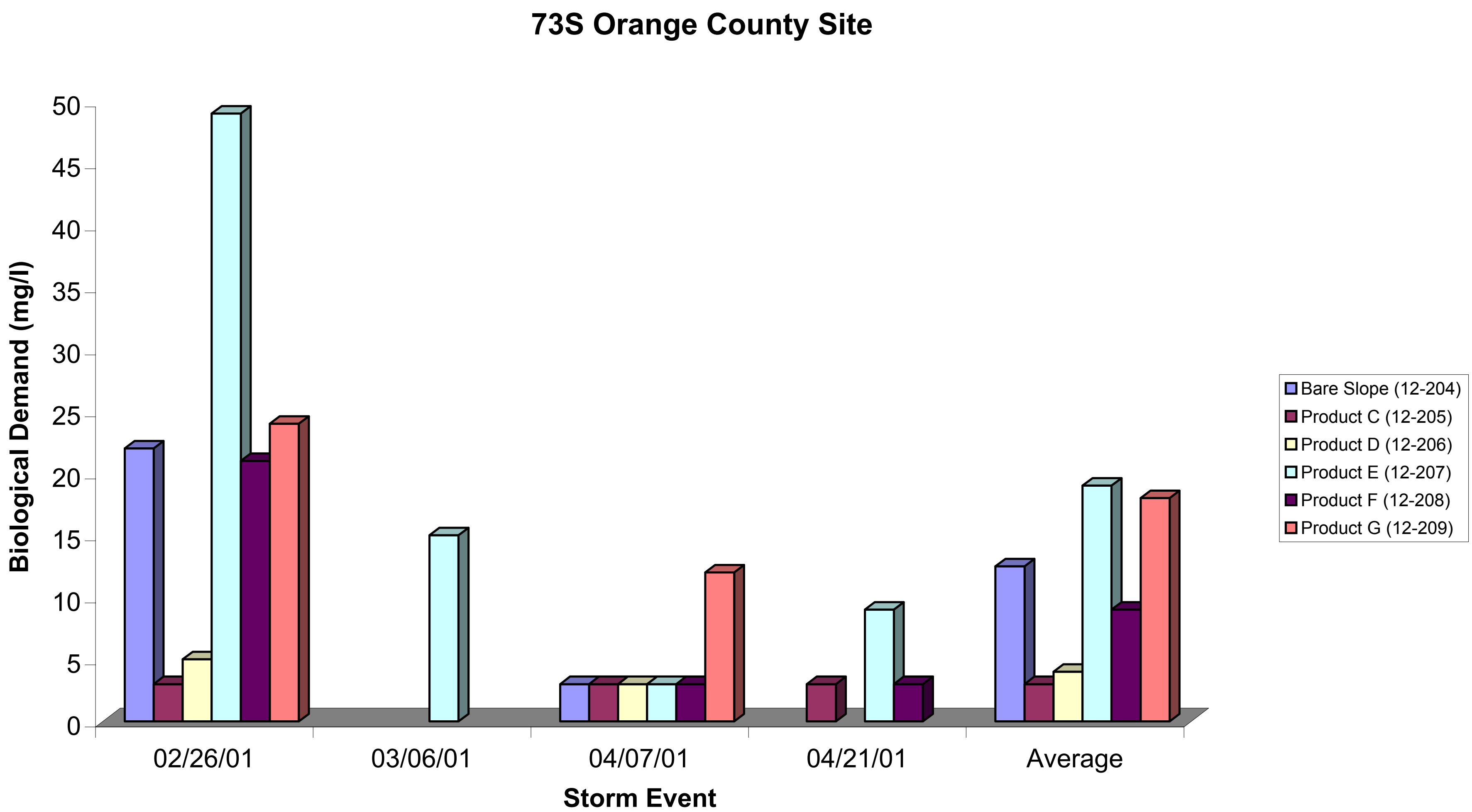


*Data point interpreted as potential product-related export

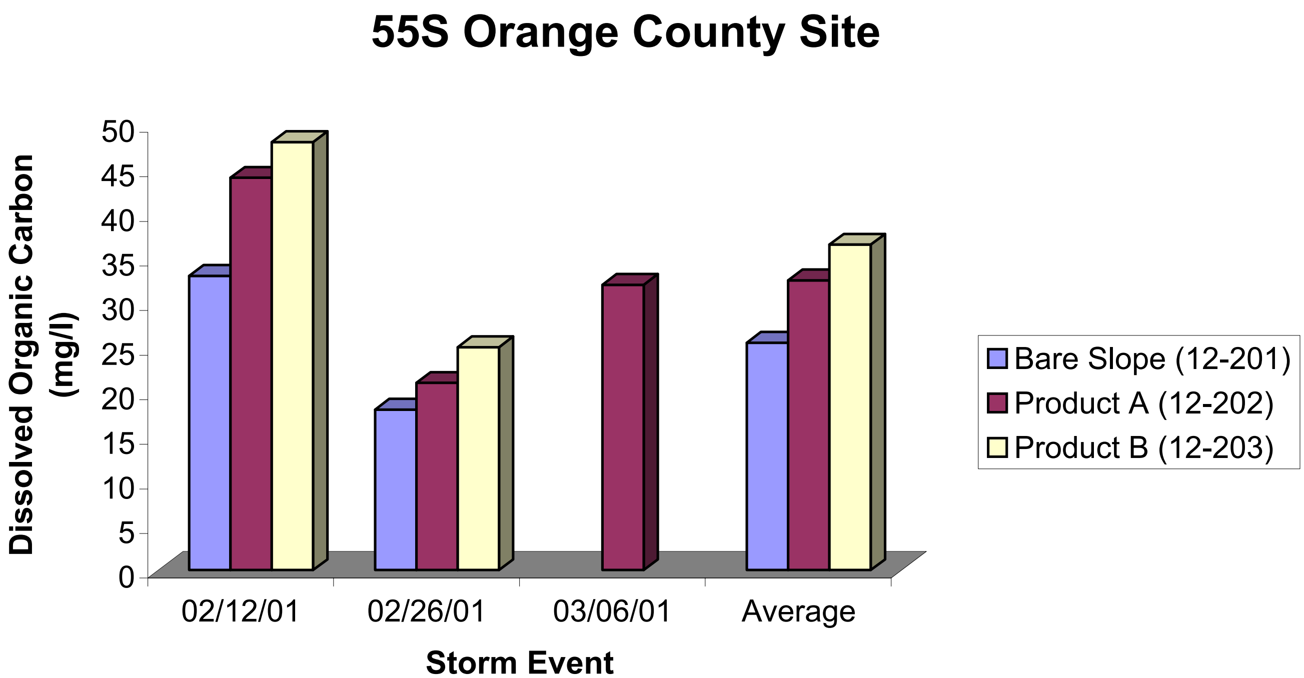
PARTICLE-BOUND ZINC vs. TOTAL SUSPENDED SOLIDS

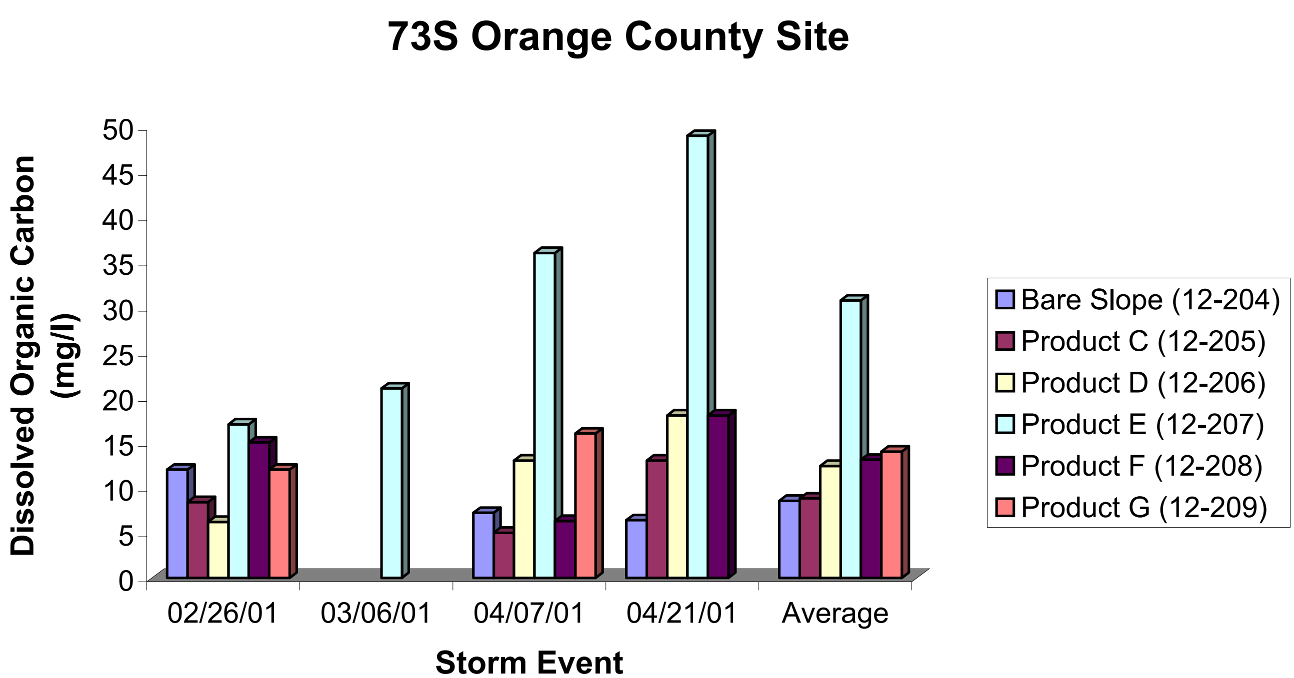
Temporary Non-Vegetative
Soil Stabilization Evaluation Study

Figure by ay	Project No. 5865.003
Date 02/12/02	Figure No. 41



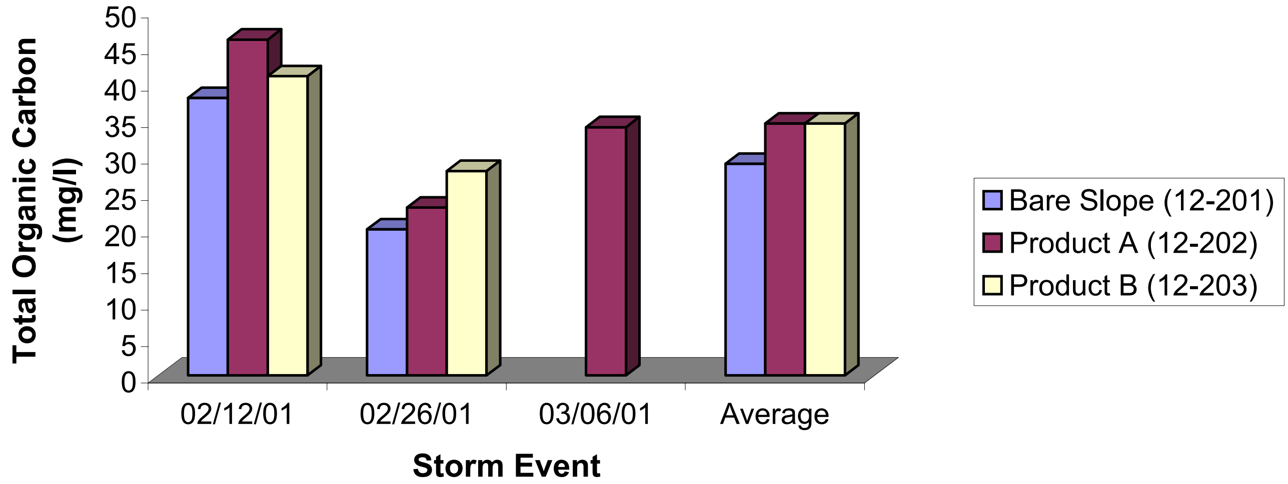
BIOLOGICAL OXYGEN DEMAND vs. STORM EVENT Temporary Non-Vegetative Soil Stabilization Evaluation Study	Figure by ay	Project No. 5865.003
	Date 02/12/02	Figure No. 42



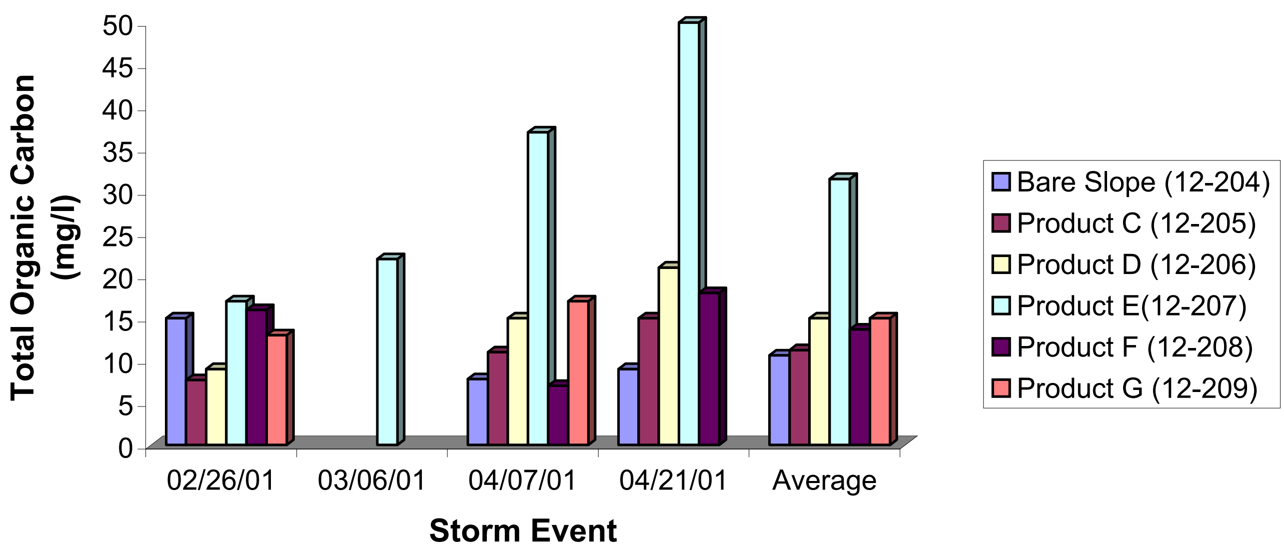


DISSOLVED ORGANIC CARBON vs. STORM EVENT Temporary Non-Vegetative Soil Stabilization Evaluation Study	Figure by ay Date 02/12/02	Project No. 5865.003 Figure No. 43

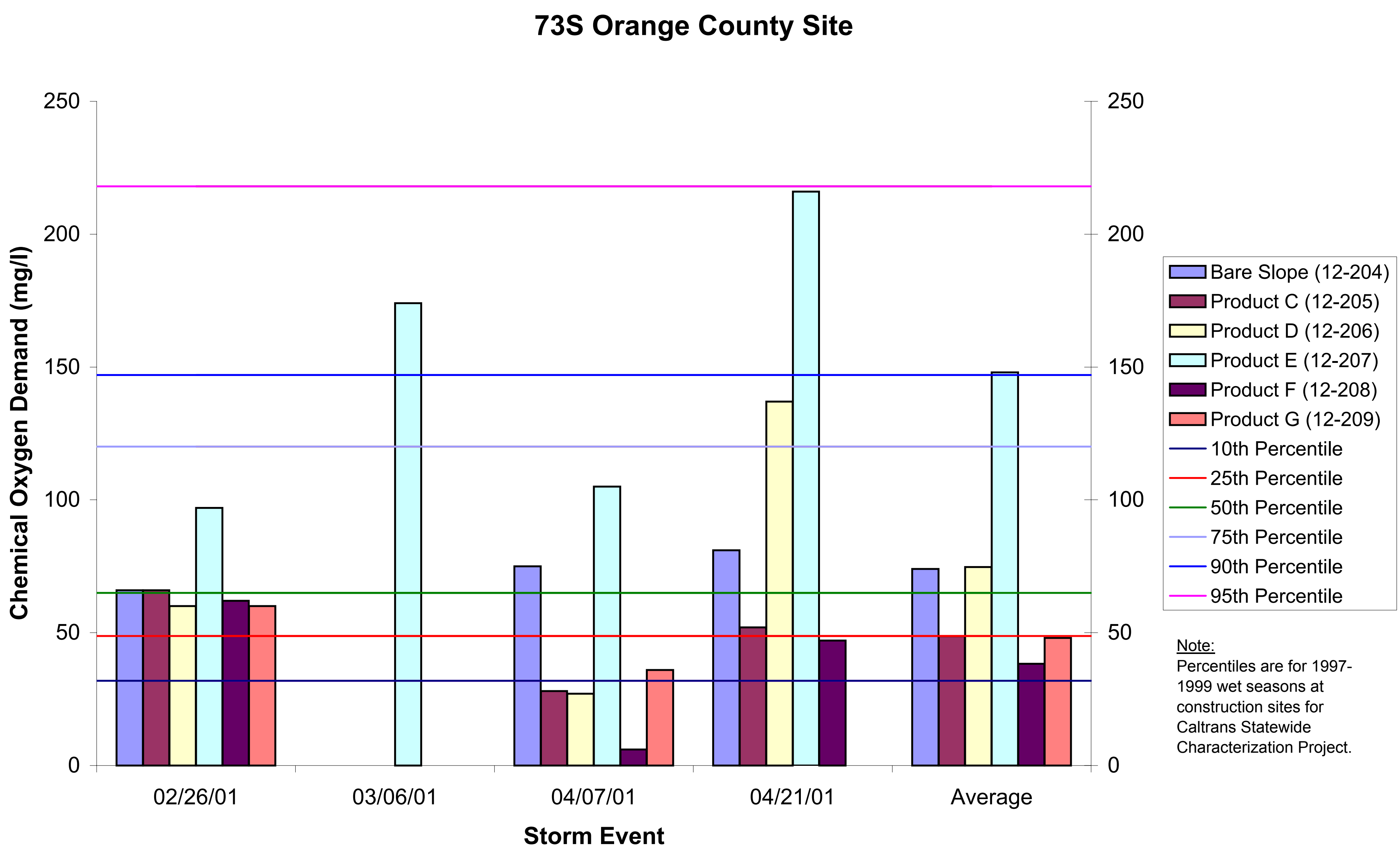
55S Orange County Site



73S Orange County Site



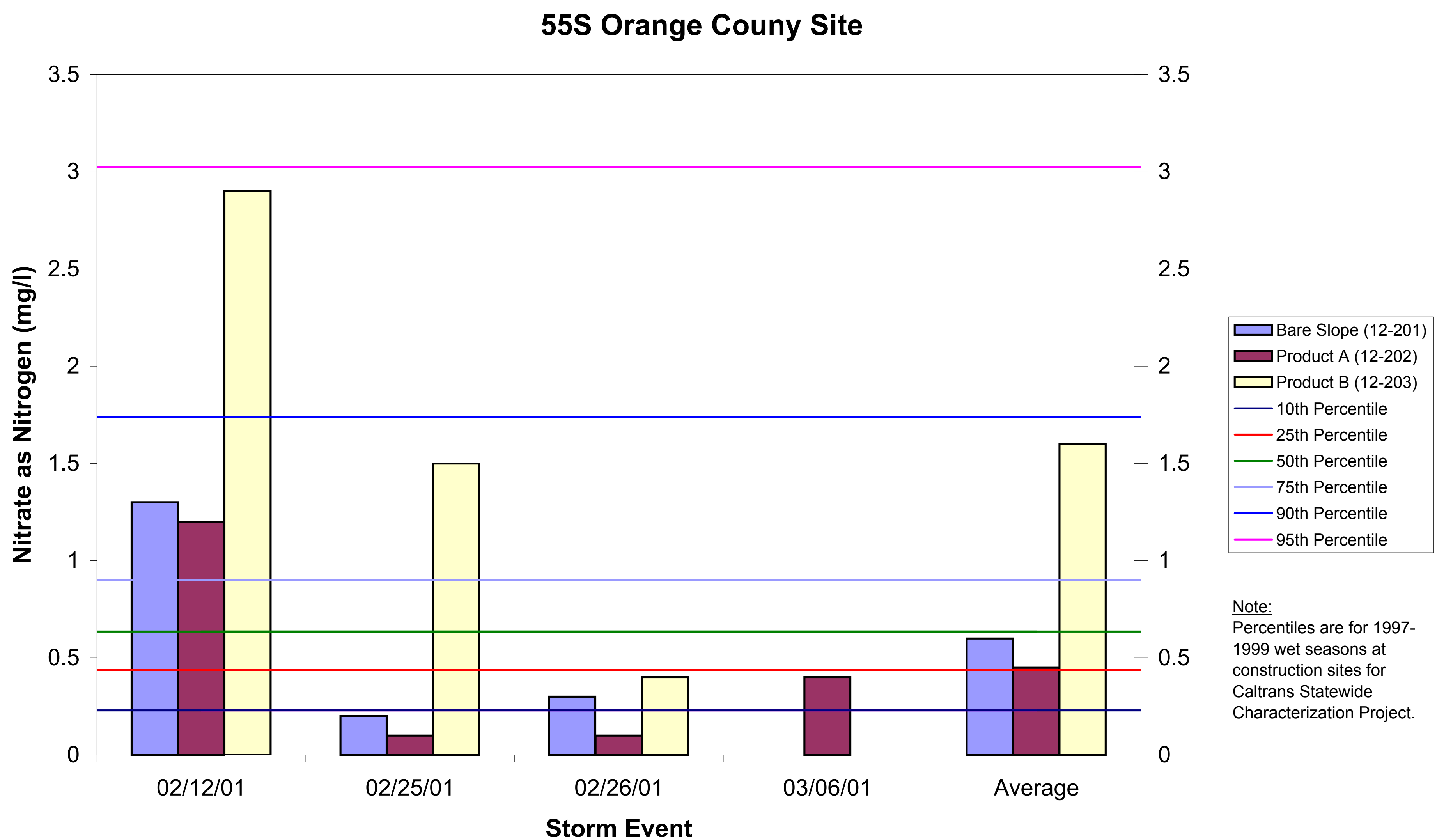
TOTAL ORGANIC CARBON vs. STORM WATER Temporary Non-Vegetative Soil Stabilization Evaluation Study	Figure by ay Date 02/12/02	Project No. 5865.003 Figure No. 44



CHEMICAL OXYGEN DEMAND vs. STORM EVENT

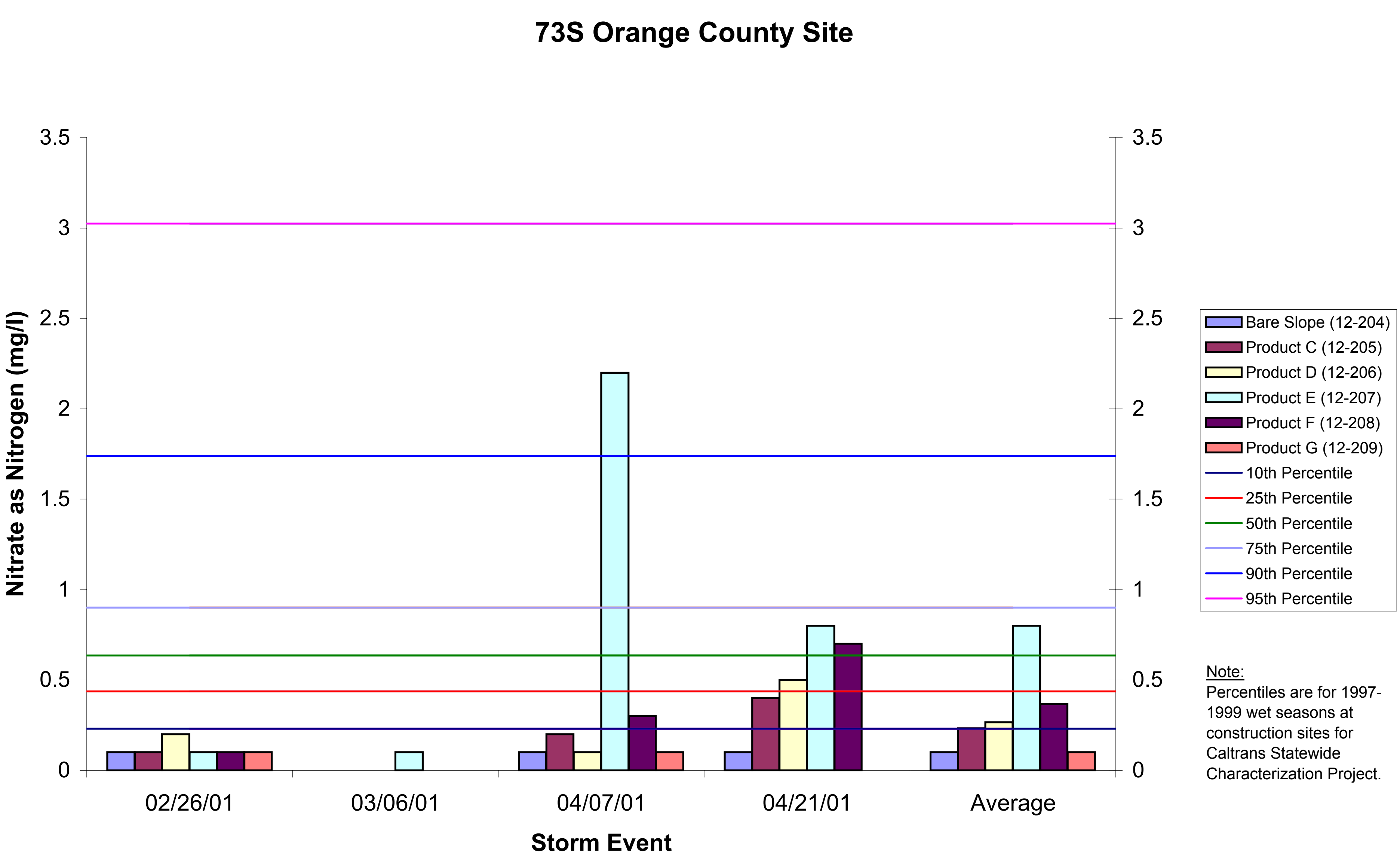
Temporary Non-Vegetative
Soil Stabilization Evaluation Study

Figure by ay	Project No. 5865.003
Date 02/12/02	Figure No. 45



*Because Nitrate as Nitrogen has a short hold-time, analysis was performed on samples collected from the first portion of the 2/26/01 storm event

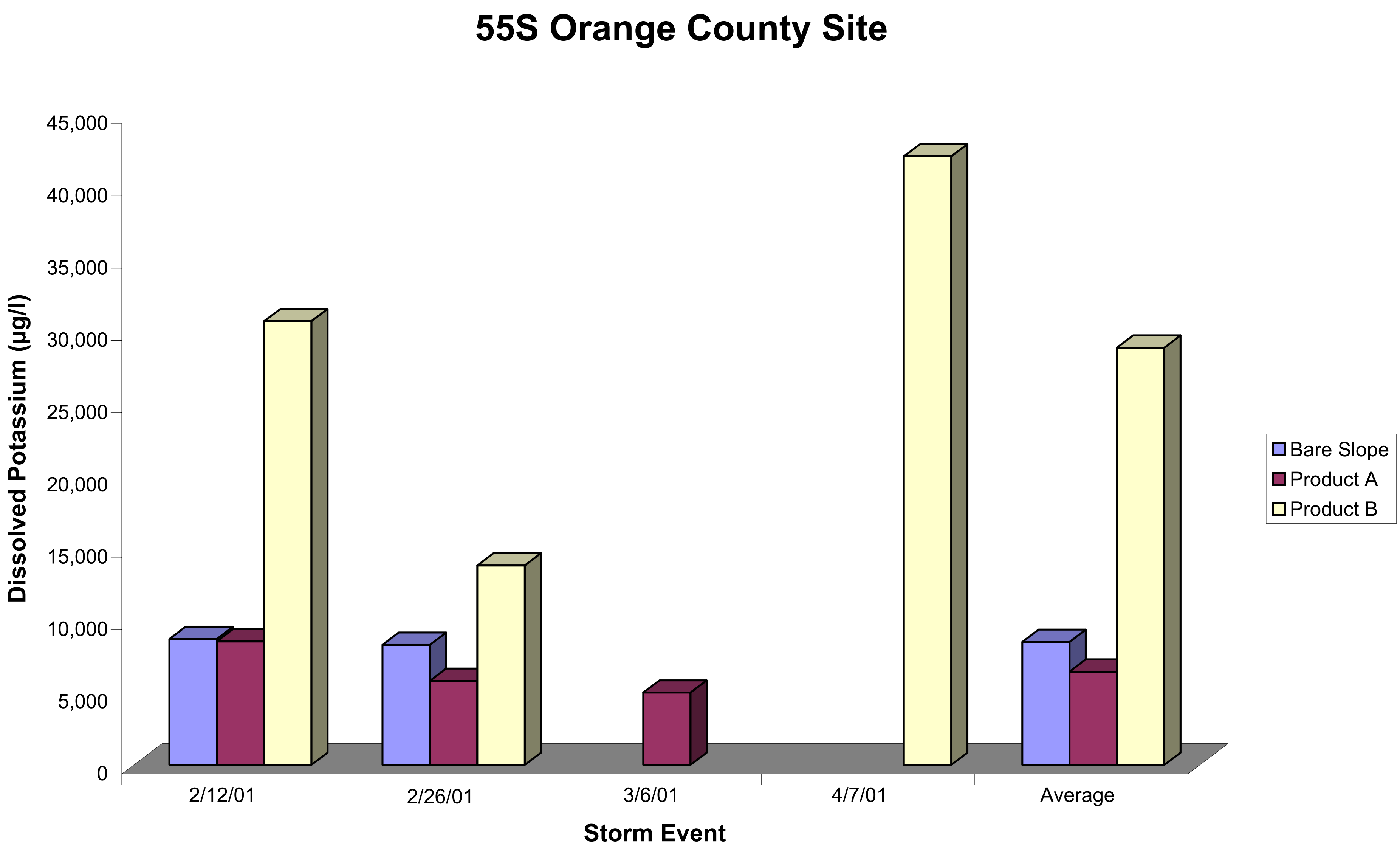
NITRATE AS NITROGEN vs. STORM EVENT Temporary Non-Vegetative Soil Stabilization Evaluation Study	Figure by ay Date 02/12/02	Project No. 5865.003 Figure No. 46



NITRATE AS NITROGEN vs. STORM EVENT

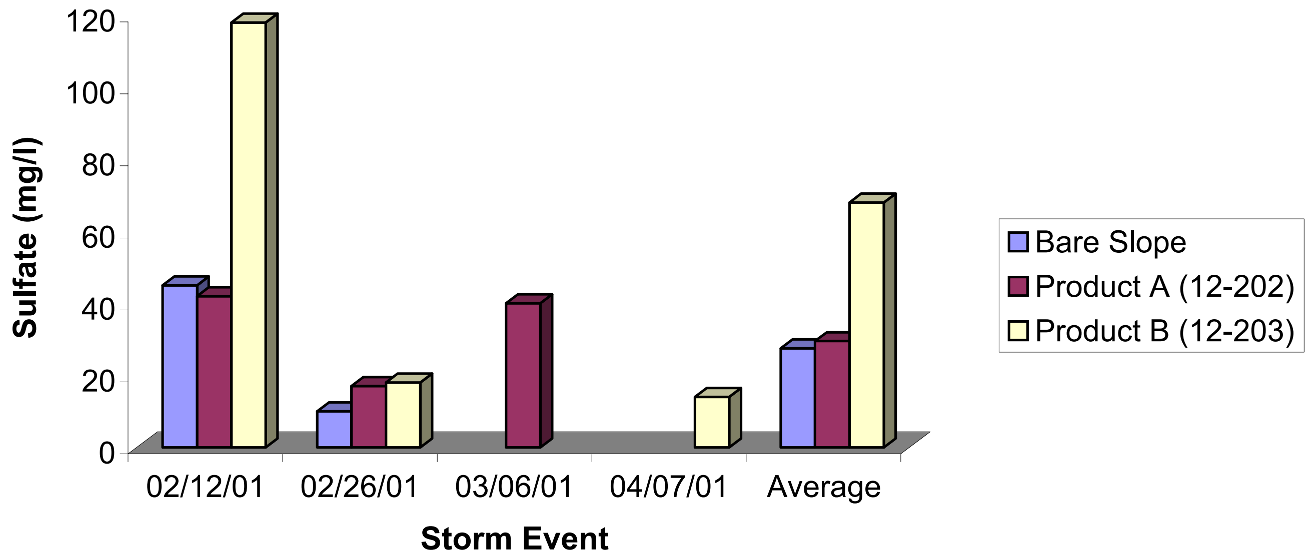
Temporary Non-Vegetative
Soil Stabilization Evaluation Study

Figure by ay	Project No. 5865.003
Date 02/12/02	Figure No. 47

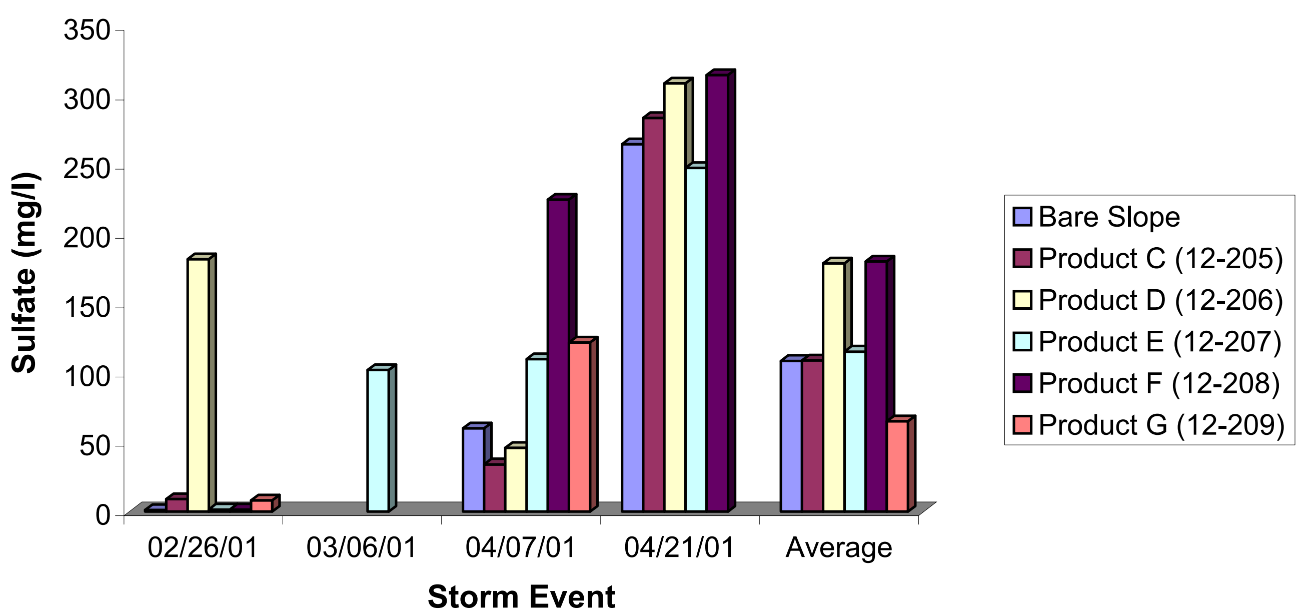


DISSOLVED POTASSIUM vs. STORM EVENT Temporary Non-Vegetative Soil Stabilization Evaluation Study	Figure by ay Date 02/12/02	Project No. 5865.003 Figure No. 48

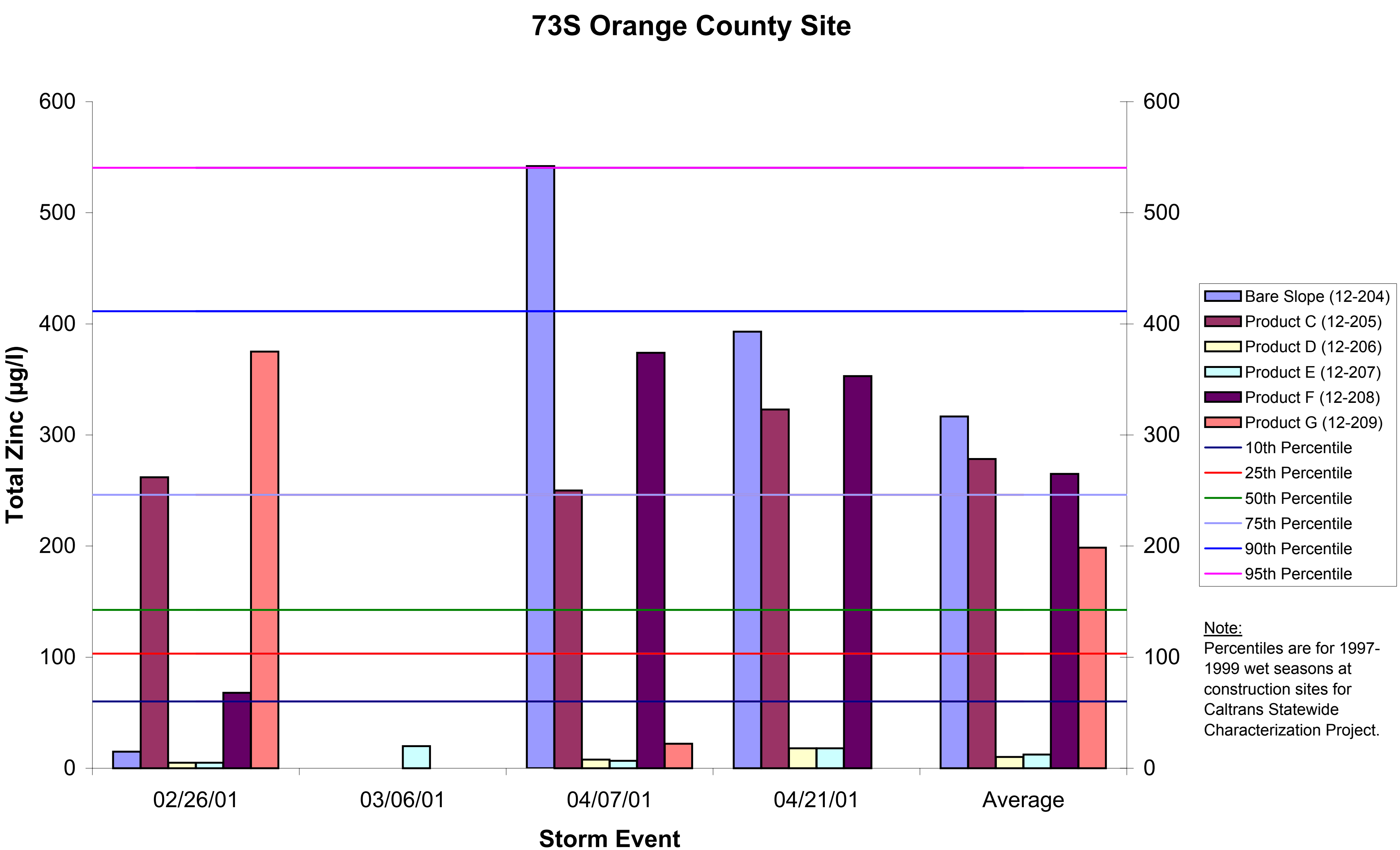
55S Orange County Site



73S Orange County Site



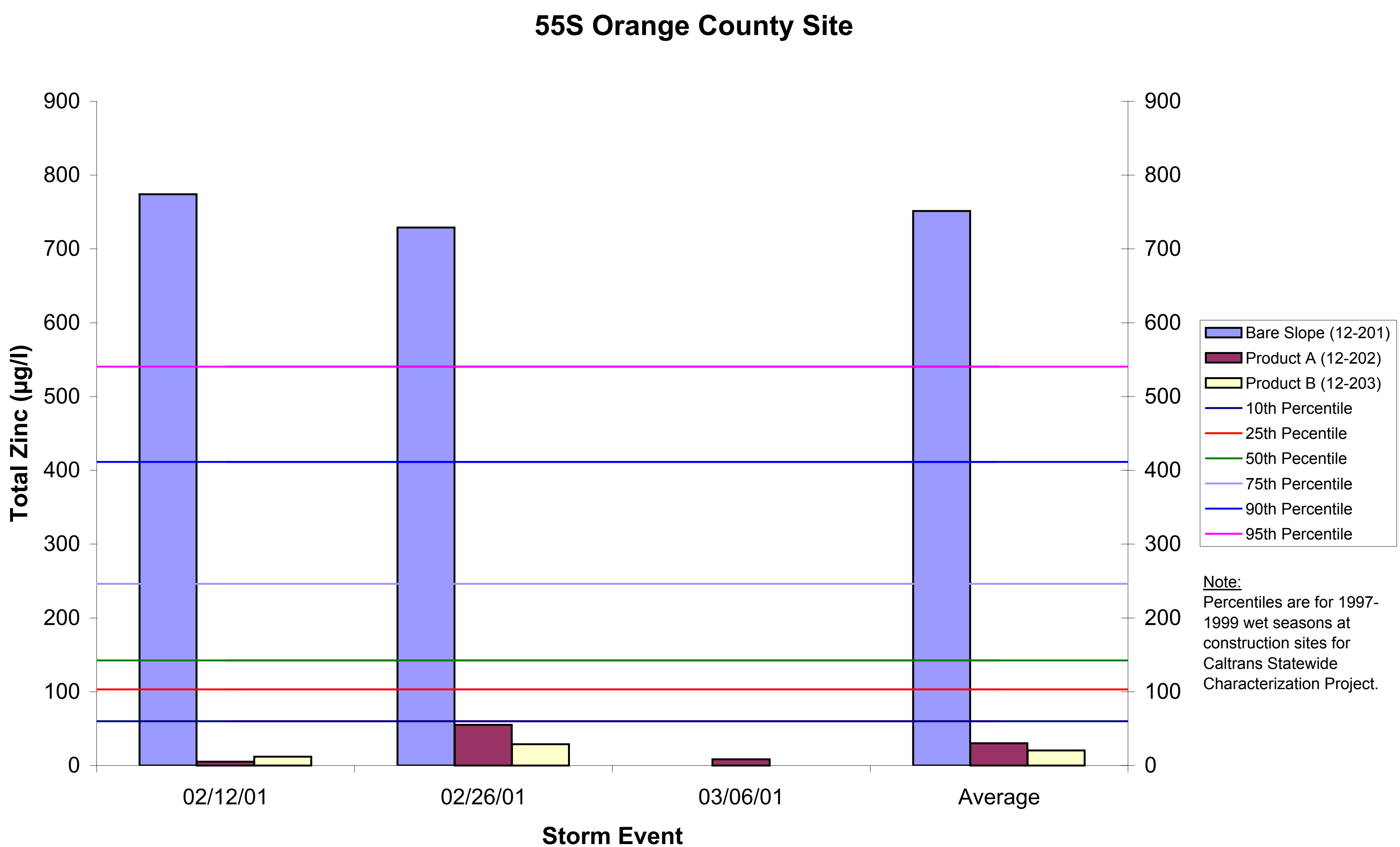
SULFATE CONCENTRATIONS vs. STORM EVENT Temporary Non-Vegetative Soil Stabilization Evaluation Study	Figure by ay Date 02/12/02	Project No. 5865.003 Figure No. 49



TOTAL ZINC vs. STORM EVENT

Temporary Non-Vegetative
Soil Stabilization Evaluation Study

Figure by ay	Project No. 5865.003
Date 02/12/02	Figure No. 50



TOTAL ZINC vs. STORM EVENT

Temporary Non-Vegetative
Soil Stabilization Evaluation Study

Figure by ay	Project No. 5865.003
Date 02/12/02	Figure No. 51

TABLES

TABLE 1

PRODUCT APPLICATION INFORMATION
TEMPORARY NON-VEGETATIVE
SOIL STABILIZATION EVALUATION STUDY
2000-2001 STUDY SEASON

Test Plot #	Product	Category Type	App. Rate	Mix Ratio	Surface Preparation Procedure	Application Method	Drying Time[1]	Date of Application
55S Study Site								
12-202	Product A	Polyacrylamid/ Acrylate	6.0 to 7.0 gal./acre	1 gal. product, 227.5 lbs. mulch, 300 gal. water per 0.1 acre	Cleared, grubbed, and tracked using bulldozer	Sprayed as liquid	4 to 8 hours	1/29/01
12-203	Product B	Acrylic Vinyl Acetate Polymer	670 gal./acre 1 gal./ 65 ft^2	4:1 ratio of water to product per 0.1 acre	Cleared, grubbed, and tracked using bulldozer	Sprayed as liquid	Overcast – 8 hrs Sunny – 2 hrs	1/29/01
73S Study Site								
12-205	Product C	Hydro-colloid polymer	80 lbs./acre	16 lbs. Product, 500 gal. water per 0.2 acre	Cleared, grubbed, and tracked using bulldozer	Sprayed as liquid	2 to 4 hours	First app 2/24/01 Second app 3/16/01
12-206	Product D	Gypsum	5000 lbs./acre	1000 lbs. product, 300 lbs. mulch, 600 gal. water per 0.2 acre	Cleared, grubbed, and tracked using bulldozer	Sprayed as liquid	4 to 8 hours	2/22/01
12-207	Product E	Polyacrylamide	25 lbs./acre	5 lbs. product, 325 lbs. mulch, 600 gal. water per 0.2 acre	Cleared, grubbed, and tracked using bulldozer	Sprayed as liquid	2 to 4 hours	2/21/01
12-208	Product F	Polyacrylamide	2-5 lbs./acre	5 oz. product, 400 gal. water per 0.2 acre	Cleared, grubbed, and tracked using bulldozer	Sprayed as liquid	4 to 8 hours	2/21/01
12-209	Product G	Cellulose Fiber	3500 lbs/acre	700 lbs. product, 1000 gal. water per 0.2 acre	Cleared, grubbed, and tracked using bulldozer	Sprayed as liquid	4 to 8 hours	2/21/01 and 2/22/01

1. Drying times obtained from URS Greiner Woodward Clyde - Soil Stabilization for Temporary Slopes Report. Drying times are dependent on weather conditions including temperature, humidity, and wind.

TABLE 2

SAMPLE COLLECTION SUMMARY
TEMPORARY NON-VEGETATIVE SOIL STABILIZATION EVALUATION STUDY
2000-2001 SEASON

Site	Plot	Product	Storm Event					Total Samples Collected and Analyzed
			02/12/01	02/26/01	03/06/01	04/07/01	04/21/01	
55S	12-201	Bare Plot	Y[1]	Y	N[2]	N	N	2
	12-202	Product A	Y	Y	Y	N	N	3
	12-203	Product B	Y	Y	N	N	N	2
73S	12-204	Bare Plot	NC[3]	Y	N	Y	Y[4,5]	3
	12-205	Product C	NC	Y	N	Y	Y[4,5]	3
	12-206	Product D	NC	Y	N	N	Y[4,5]	2
	12-207	Product E	NC	Y	Y	Y	Y	4
	12-208	Product F	NC	Y	N	Y	Y	3
	12-209	Product G	NC	Y	N	Y	N	2

1. Y = Sample collected and analyzed for full suite of constituents described in Study Plan, unless otherwise noted.
2. N = Sample not collected due to insufficient storm water runoff.
3. NC = Plot not constructed at time of storm event.
4. Volume of sample collected not sufficient for BOD analysis.
5. Ammonia grab sample not collected.

TABLE 3

STORM EVENT DATA
TEMPORARY NON-VEGETATIVE SOIL STABILIZATION EVALUATION STUDY
2000-2001 STUDY SEASON

TEST PLOT	DATE	TOTAL RAINFALL (inches)
12-201	02/12/01	1.38
	02/26/01	1.83
	03/06/01	0.31
	04/07/01	0.3
	04/21/01	0.16
12-202	02/12/01	1.35
	02/26/01	1.81
	03/06/01	0.31
	04/07/01	0.29
	04/21/01	0.17
12-203	02/12/01	1.32
	02/26/01	1.78
	03/06/01	0.33
	04/07/01	0.29
	04/21/01	0.17
12-204	02/12/01	na
	02/26/01	2.31
	03/06/01	0.38
	04/07/01	0.72
	04/21/01	0.31
12-205	02/12/01	na
	02/26/01	2.31
	03/06/01	0.38
	04/07/01	0.63
	04/21/01	0.31
12-206	02/12/01	na
	02/26/01	2.17
	03/06/01	0.4
	04/07/01	0.64
	04/21/01	0.3
12-207	02/12/01	na
	02/26/01	2.34
	03/06/01	0.43
	04/07/01	0.71
	04/21/01	0.32
12-208	02/12/01	na
	02/26/01	2.26
	03/06/01	0.41
	04/07/01	0.62
	04/21/01	0.28
12-209	02/12/01	na
	02/26/01	2.45
	03/06/01	0.43
	04/07/01	0.64
	04/21/01	0.3

na - no storm data available. Site under construction at time of storm event.

TABLE 4

SOIL SAMPLE RESULTS
TEMPORARY NON-VEGETATIVE
SOIL STABILIZATION EVALUATION STUDY
2000-2001 STUDY SEASON

Site ID	Test Plot	Al[1] (mg/kg)[18]	Al(D) (mg/kg)	As[2] (mg/kg)	As(D) (mg/kg)	Ba[3] (mg/kg)	Ba(D) (mg/kg)	Cd[4] (mg/kg)	Cd(D) (mg/kg)	Ca[5] (mg/kg)	Ca(D) (mg/kg)	Cr[6] (mg/kg)	Cr(D) (mg/kg)	Cu[7] (mg/kg)	Cu(D) (mg/kg)	Fe[8] (mg/kg)	Fe(D) (mg/kg)	Hg[9] (mg/kg)	Hg(D) (mg/kg)	K[10] (mg/kg)	K(D) (mg/kg)	Mg[11] (mg/kg)	Mg(D) (mg/kg)	Mn[12] (mg/kg)	Mn(D) (mg/kg)	Na[13] (mg/kg)	Na(D) (mg/kg)	Ni[14] (mg/kg)	Ni(D) (mg/kg)	Pb[15] (mg/kg)	Pb(D) (mg/kg)	V[165] (mg/kg)	V(D) (mg/kg)	Zn[17] (mg/kg)	Zn(D) (mg/kg)
55S Study Site																																			
12-201	Bare Plot	NA[19]	NA	3.0	<0.80	NA	<0.80	0.37	<0.80	22000	240	10	<0.80	11	<0.80	7700	45	<0.20	<0.20	1400	32	3600	38	NA	NA	910	710	8.1	<0.80	7.5	<0.80	NA	NA	34.5	<0.80
12-201	Bare Plot	NA	NA	4.3	<0.80	NA	<0.80	0.22	<0.80	48000	160	17	<0.80	15	<0.80	18000	47	<0.20	<0.20	2500	28	7100	25	NA	NA	750	640	13	<0.80	8.9	<0.80	NA	NA	52.0	<0.80
12-201	Bare Plot	NA	NA	4.0	<0.80	NA	<0.80	0.45	<0.80	24000	260	16	<0.80	16	<0.80	13000	58	<0.20	<0.20	2400	30	5300	32	NA	NA	700	620	12	<0.80	9.8	<0.80	NA	NA	51.0	<0.80
	Average			**3.77**				**0.35**		**31333**	**220**	**14**		**14**		**12900**	**50**			**2100**	**30**	**5333**	**32**			**787**	**657**	**11**		**9**				**46**	
73S Study Site																																			
12-204	Bare Plot	2700	17	1.8	<0.80	21	<0.80	0.47	<0.80	NA	NA	10	<0.80	5.1	<0.80	NA	NA	NA	NA	NA	NA	NA	NA	150	49	NA	NA	7.3	<0.80	2.2	<0.80	12	<0.80	30.7	<0.80
12-204	Bare Plot	2600	27	1.7	<0.80	18	<0.80	0.40	<0.80	NA	NA	8.9	<0.80	3.9	<0.80	NA	NA	NA	NA	NA	NA	NA	NA	150	4.1	NA	NA	5.7	<0.80	1.8	<0.80	12	<0.80	25.0	<0.80
12-204	Bare Plot	300	9.0	2.1	<0.80	23	<0.80	0.44	<0.80	NA	NA	11	<0.80	6.2	<0.80	NA	NA	NA	NA	NA	NA	NA	NA	140	2.8	NA	NA	7.3	<0.80	2.3	<0.80	16	<0.80	24.8	<0.80
	Average	**1867**	**17.7**	**1.9**		**21**		**0.44**				**10.0**		**5.1**										**146.7**	**18.6**			**6.8**		**2.1**		**13.3**		**26.8**	

1. Al = aluminum.
2. As = arsenic.
3. Ba = barium.
4. Cd = cadmium.
5. Ca = calcium.
6. Cr = chromium.
7. Cu = copper.
8. Fe = iron.
9. Hg = mercury.
10. K = potassium.
11. Mg = magnesium.
12. Mn = manganese.
13. Na = sodium.
14. Ni = nickel.
15. Pb = lead.
16. V = vanadium.
17. Zn = zinc.
18. mg/kg = milligrams per kilogram
19. NA = not analyzed.

TABLE 5

PRODUCT SAMPLE RESULTS
TEMPORARY NON-VEGETATIVE
SOIL STABILIZATION EVALUATION STUDY
2000-2001 STUDY SEASON

Site ID	Test Plot	Al (µg/l)[18]	Al(D) (µg/l)	As (µg/l)	As(D) (µg/l)	Ba (µg/l)	Ba(D) (µg/l)	Cd (µg/l)	Cd(D) (µg/l)	Ca (µg/l)	Ca(D) (µg/l)	Cr (µg/l)	Cr(D) (µg/l)	Cu (µg/l)	Cu(D) (µg/l)	Fe (µg/l)	Fe(D) (µg/l)	Hg (ng/l)[19]	Hg(D) (ng/l)	K (µg/l)	K(D) (µg/l)	Mg (µg/l)	Mg(D) (µg/l)	Mn (µg/l)	Mn(D) (µg/l)	Na (µg/l)	Na(D) (µg/l)	Ni (µg/l)	Ni(D) (µg/l)	Pb (µg/l)	Pb(D) (µg/l)	V (µg/l)	V(D) (µg/l)	Zn (µg/l)	Zn(D) (µg/l)
55S Study Site																																			
12-202	Product A	NA	NA	<5.0	<5.0	NA	NA	<2.0	<5.0	560	550	<5.0	<5.0	<2.0	<10	200	130	1.5	<0.80	400	340	310	290	NA	NA	26000	23000	<2.0	<10	<0.20	<1.0	NA	NA	25	22
12-203	Product B	NA	NA	<5.0	<5.0	NA	NA	<2.0	<5.0	5900	5300	<5.0	<5.0	<2.0	<10	4000	3800	<0.20	<0.80	1400	1300	980	930	NA	NA	61000	60000	<2.0	<10	<0.20	<1.0	NA	NA	120	120
73S Study Site																																			
12-205	Product C	1100	320	<5.0	<5.0	6.0	<5.0	<2.0	<5.0	NA	NA	<5.0	<5.0	<2.0	<10	NA	NA	NA	NA	NA	NA	NA	NA	6.3	<10	NA	NA	<2.0	<10	<0.20	<1.0	42	15	54	47
12-206	Product D	470	100	<5.0	<5.0	180	170	<2.0	<5.0	NA	NA	<5.0	<5.0	<2.0	<10	NA	NA	NA	NA	NA	NA	NA	NA	2400	2300	NA	NA	22	18	8.9	<1.0	2.5	<10	97	77
12-207	Product E	390	200	78	64	130	90	2.3	<5.0	NA	NA	43	24	92	57	NA	NA	NA	NA	NA	NA	NA	NA	630	510	NA	NA	11	<10	47	21	3.7	<10	750	570
12-208	Product F	62	60	7.8	0.54	1.1	<0.50	0.33	0.33	NA	NA	35	34	0.95	<1.0	NA	NA	NA	NA	NA	NA	NA	NA	0.34	<1.0	NA	NA	0.69	<1.0	<0.20	<0.50	1.0	<1.0	8.1	2.2
12-209	Product G	5700	280	<5.0	<5.0	240	240	<2.0	<5.0	NA	NA	10	<5.0	2.7	<10	NA	NA	NA	NA	NA	NA	NA	NA	1200	1100	NA	NA	32	23	<0.20	<1.0	15	<10	480	390

1. Al = aluminum.
2. As = arsenic.
3. Ba = barium.
4. Cd = cadmium.
5. Ca = calcium.
6. Cr = chromium.
7. Cu = copper.
8. Fe = iron.
9. Hg = mercury.
10. K = potassium.
11. Mg = magnesium.
12. Mn = manganese.
13. Na = sodium.
14. Ni = nickel.
15. Pb = lead.
16. V = vanadium.
17. Zn = zinc.
18. µg/l = micrograms per liter.
19. ng/l = nanograms per liter.
20. NA = not analyzed.

TABLE 6

SUMMARY OF VEGETATION ON PLOTS
TEMPORARY NON-VEGETATIVE SOIL STABILIZATION EVALUATION STUDY
2000-2001 STUDY SEASON

TYPE	PRODUCT	Study Site	Approximate Percent Vegetation Cover: 02/12/2001 Storm	02/26/2001 Storm	03/06/2001 Storm	04/07/2001 Storm	04/21/2001 Storm
POLYACRYLAMID/ACRYLATE	Product A (12-202)	55S	0	<25	<25	<25	<25
ACRYLIC VINYL ACETATE POLYMER	Product B (12-203)	55S	0	<25	<25	<25	<25
HYDRO-COLLOID POLYMER	Product C (12-205)	73S	NC [1]	0	0	<25	<25
GYPSUM	Product D (12-206)	73S	NC	0	0	<25	<25
POLYACRALAMIDE	Product E (12-207)	73S	NC	0	0	<25	<50
POLYACRALAMIDE	Product F (12-208)	73S	NC	0	0	<25	<50
CELLULOSE FIBER	Product G (12-209)	73S	NC	0	0	<25	<25

1. NC = Plot not constructed at time of storm event.

TABLE 7 (continued)

STORM WATER QUALITY RUNOFF SUMMARY
TEMPORARY NON-VEGETATIVE
SOIL STABILIZATION EVALUATION STUDY
2000-2001 STUDY SEASON

Site ID	Sample Date	BOD[1] (mg/l)[15]	COD[2] (mg/l)	DOC[3] (mg/l)	EC[4] (µmhos/cm)[16]	Hardness as $CaCO_3$ (mg/l)	NH_3-N[5] (mg/l)	NO_3-N[6] (mg/l)	ortho-P[7] (mg/l)	P[8] (mg/l)	pH (_pH units)	SO_4[9] (mg/l)	TDS[10] (mg/l)	TKN[11] (mg/l)	TOC[12] (mg/l)	TPH (Heavy Oil)[13] (mg/l)	TSS[14] (mg/l)
12-201	2/12/01	NA[17]	NA	33	345	265	0.27	1.3	< 0.03	0.16	9.6	45	522	7.1	38	< 50	8119
12-201[18]	2/26/01	NA	NA	18	129	114	< 0.1	0.3	< 0.03	5.25	8.7	10	208	1.5	20	NA	9581
12-202	2/12/01	NA	NA	44	340	57	0.12	1.2	< 0.03	0.11	10.1	42	212	1.7	46	< 50	52
12-202[19]	2/26/01	NA	NA	21	154	32	0.2	< 0.1	< 0.03	0.43	9.1	17	156	0.9	23	NA	269
12-202	3/6/01	NA	NA	32	218	38	0.12	0.4	< 0.03	0.14	8.2	40	194	1.3	34	< 50	72
12-203	2/12/01	NA	NA	48	645	78	0.3	2.9	< 0.03	0.13	10.4	118	418	2.4	41	< 50	70
12-203[20]	2/26/01	NA	NA	25	275	250	0.2	0.4	0.07	0.34	8.8	18	272	0.8	28	NA	201
12-204[21]	2/26/01	22	66	12	131	21	0.2	< 0.1	< 0.03	0.28	10.3	< 1	122	0.3	15	NA	149
12-204	4/7/01	< 3	75	7.2	170	182	NA	< 0.1	0.07	12.3	8.2	60	125	7.5	7.8	NA	9510
12-204	4/21/01	NA	81	6.4	486	280	NA	< 0.1	0.07	13.1	6.3	265	442	15.9	9	NA	40180
12-205[22]	4/7/01	< 3	28	5	120	102	NA	0.2	0.13	0.24	8	34	99	5.6	11	NA	4392
12-205	4/21/01	< 3	52	13	558	558	NA	0.4	0.07	11.6	6	284	391	7.9	15	NA	6023
12-206	2/26/01	5	60	6.2	288	43	< 0.1	0.2	< 0.03	0.06	9.4	182	264	0.5	9	NA	188
12-206	4/21/01	NA	137	18	646	260	NA	0.5	0.03	0.2	7.8	309	485	0.5	21	NA	147
12-207[23]	2/26/01	49	97	17	117	37	0.2	< 0.1	< 0.03	0.19	9.9	1.4	128	0.6	17	NA	150
12-207	3/6/01	15	174	21	207	100	0.2	0.1	< 0.03	0.31	7.3	102	196	0.5	22	NA	300
12-207	4/7/01	< 3	105	36	292	110	0.3	2.2	0.38	0.05	8.9	110	262	1.5	37	NA	54
12-207	4/21/01	9	216	49	546	240	NA	0.8	0.03	0.26	7	248	494	1.5	50	NA	218
12-208	2/26/01	21	62	15	150	26	0.2	< 0.1	0.1	3.3	10	1.4	144	0.4	16	NA	970
12-208	4/7/01	< 3	6	6.3	457	277	0.3	0.3	0.05	0.17	8	225	454	3.8	7	NA	4096
12-208	4/21/01	< 3	47	18	634	272	NA	0.7	0.1	7.9	7	315	471	4.8	18	NA	4560
12-209	2/26/01	24	60	12	152	41	0.2	< 0.1	< 0.03	0.98	10.1	8	144	0.8	13	NA	361
12-209	4/7/01	12	36	16	308	117	NA	< 0.1	0.11	0.29	8	122	288	1.2	17	NA	278

1. BOD = biological oxygen demand.
2. COD = chemical oxygen demand.
3. DOC = dissolved oxygen demand.
4. EC = electrical conductivity.
5. NH3-N = nitrogen ammonia (as N).
6. NO3-N = nitrogen nitrate (as N).
7. Ortho-P = phosphorus, total orthophosphate (as P).
8. P = phosphorus, total (as P).
9. SO4 = sulfate (as SO4).
10. TDS = total dissolved solids
11. TKN = total kjeldahl nitrogen.
12. TOC = total organic carbon.
13. TPH (heavy oil) = TPH as heavy oil.
14. TSS = total dissolved solids.
15. mg/l = milligrams pr liter.
16. µmhos/cm = micromhos/centimeter.
17. NA = not analyzed.
18. Due to hold time constraints, first portion of sample was analyzed for NH_3-N, NO_3-N, ortho-P, pH, and TPH. Results were 0.1 mg/l, 0.2 mg/l, 0.31 mg/l, 9.2 pH units, and <50 mg/l, respectively.
19. Due to hold time constraints, first portion of sample was analyzed for NH_3-N, NO_3-N, ortho-P, pH, and TPH. Results were 0.13 mg/l, <0.1 mg/l, <0.03 mg/l, 9.1 pH units, and <50 mg/l, respectively.
20. Due to hold time constraints, first portion of sample was analyzed for NH_3-N, NO_3-N, ortho-P, pH, and TPH. Results were 0.11 mg/l, 1.5 mg/l, <0.03 mg/l, 9.1 pH units, and <50 mg/l, respectively.
21. Due to hold time constraints, first portion of sample was analyzed for NO_3-N, ortho-P, and pH. Results were 0.1 mg/l, 1.5 mg/l, 0.08 mg/l, 10.5 pH units, respectively.
22. Results from the 2/25/01 storm event for site 12-205 are not included because the product did not fully cure prior to the storm event.
23. The grab ammonia sample was collected and sent to the laboratory prior to the end of the storm. Result was 0.13 mg/l.

TABLE 8

PRODUCT INFORMATION AND PERFORMANCE SUMMARY
TEMPORARY NON-VEGETATIVE SOIL STABILIZATION EVALUATION STUDY
2000-2001 STUDY SEASON

			Product Information									Erosion Control Performance [10]						Storm Water Quality Performance
TYPE	PRODUCT (Plot)	Study Site	Availability [1]	Antecedent Soil Moisture [2]	Installed Cost Per Acre [3]	Mode of Application [4]	Application Conditions [5]	Ease of Cleanup [6]	Primary Use [7]	Suitability for Vehicular Traffic [8]	Length of Drying Time (hrs)	02/12/2001 Storm	02/26/2001 Storm	03/06/2001 Storm [9]	04/07/2001 Storm	04/21/2001 Storm	Longevity - Number of Storms [11]	Possible Product Related Export
POLYACRYLAMID/ACRYLATE	Product A (12-202)	55S	S	ANY	$450	H	NR	E	EC	NS	4 to 8	H	H	H	H	H	5	None [12]
ACRYLIC VINYL ACETATE POLYMER	Product B (12-203)	55S	S	D/M	$1,300	H	NR	M	EC	S	2 to 8	H	H	H	H	H	5	SO_4, K, NO_3
HYDRO-COLLOID POLYMER	Product C (12-205)	73S	S	D/M	$450	H	NR	E	T/EC/V	NS	2 to 4	NC	L	H	L	L	1	None [13]
GYPSUM	Product D (12-206)	73S	S	D/M	$900	H	NR/W	M	EC/V	NS	4 to 8	NC	H	H	H	H	4	SO_4
POLYACRALAMIDE	Product E (12-207)	73S	S	D/M	$650	H	NR	E	T/EC/V	NS	2 to 4	NC	H	H	M	M	2	NO_3,BOD,COD DOC, TOC
POLYACRALAMIDE	Product F (12-208)	73S	S	N/S	$450	W/S	NR	E	EC	NS	4 to 8	NC	H	H	L	L	1	SO_4
CELLULOSE FIBER	Product G (12-209)	73S	S	N/S	$1,100	H	NR	M	EC	NS	4 to 8	NC	H	H	H	H	4	Zn

1. Availability - S = product typically available within 3 to 5 working days from suppliers.
2. Antecedent Soil Moisture - Optimum soil moisture condition for application of product - N/S = not specified; D/M = dry to moist; ANY = any soil moisture that will not promote runoff off of the product during application.
3. Installed Cost Per Ha - Costs from Table 1-2 URS Greiner, November 1999, and adjusted for 3 percent annual infiltration for 2001.
4. Mode of Application - H = Hydroseeder; W/S = Water truck or water tank with spray rig.
5. Applicaton Conditions - R = can be applied during rain; NR = do not apply during rain; W = do not apply when wind gusts exceed 25 mph.
6. Ease of Cleanup - E = easy to cleanup equipment and overspray with strong stream of water when product is wet or dry; M = requires cleanup with water when product is wet, difficult to cleanup when product is dry.
7. Primary Use - EC = erosion control; T = tackifier; V = vegetation established.
8. Suitability for Vehicular Traffic - NS = not suited; S = suited for dust control along roadways.
9. The 3/06/01 storm event was of low intensity and produced minimal runoff from all plots. Consequently, there was no to minor erosion observed on each plot and the erosion performance of each plot was ranked as "high."
10. Erosion Control Performance - L = Low, M = Medium; H = High, Criteria defined in Section 6.1 of report.
11. Longevity - Number of storms observed in which the product showed more soil erosion control effectiveness then untreated bare soil plot.
12. No constituents identified in 2000-2001 study season.

APPENDIX A

STORM WATER SAMPLE PREPARATION AND COLLECTION

APPENDIX A

STORM WATER SAMPLE PREPARATION AND COLLECTION

The storm water sample preparation and collection procedures were conducted in general accordance with the Study Plan and SAP. The following provides a summary of the general storm water sampling procedures including selection of the storm to be monitored, field measurements and observations made during each storm monitoring event, and the methods used to collect, preserve, and handle storm water samples.

A.1 STORM SELECTION

Between the end of January and the end of April, 2001, weather forecasts and storm development information provided by the National Weather Service and other weather service related sources were tracked by project personnel to predict if a storm event likely would qualify as an event sufficient to implement monitoring. Storm events were selected for monitoring based on the following criteria provided in the *Caltrans Guidance Manual: Storm Water Monitoring Protocol, Second Edition*.

- The storm event must have a minimum quantity of rain forecasted. The general guideline used during this study was storms predicted to produce more than 0.10 inch of rainfall for arid areas, such as the two study sites in southern California.

- The storm event must be preceded by a study-specific minimum dry period of 24 hours with a period of 72 hours preferred.

Once a storm was forecast, the decision to either select ("go") or reject ("no go") a storm event was based on the amount of rain forecast and the probability of the storm occurring as outlined below.

- If the forecast for a storm event was less than 0.10 inch of rainfall and less than 50 percent probability, the storm was classified as a "no go" event.

- If the forecast for a storm event was 0.10 inch of rainfall or greater with between 50 and 75 percent probability, the Caltrans project manager assessed the available storm forecast information and made a decision as to whether a given storm was a "go" or "no go" event.

- If the forecast for a storm event was 0.10 inch of rainfall or greater with a 75 to 100 percent probability, the storm was classified as a “go” event.

For the period from January to April, a total of seven storm forecasts met the conditions for a “go” event. Of the seven forecasted “go” events, five storms produced sufficient rain to collect samples from at least one test plot.

A.2 FIELD MEASUREMENTS

The following subsections describe methods used to collect field measurements during the storm water sampling events.

A.2.1 Physical Water Quality Parameters

During each selected storm event, at least one temperature, pH, and specific electrical conductance measurement was attempted from each storm water sampling location using a hand-held field meter. Due to varying rain and runoff intensities at the study sites, physical water quality parameters were not collected from every test plot during every storm. The field meters were calibrated and operated in accordance with the manufacturer’s specifications. The field measurements and calibration data were recorded on a Field Data Log Sheet that was completed for each sampling location.

A.2.2 Precipitation

“Tipping bucket” rain gauges were used to collect rainfall data and to initiate sample collection when used in conjunction with automated sampling equipment. These type of rain gauges function by collecting rainfall in a “bucket” and “tipping” it when full. Each time the bucket is tipped, a switch momentarily closes and then resets the rain gauge to start the process again. A data logger/controller counts each switch closure to track rainfall totals. The rain gauges were mounted on the top of each sampling system enclosure. The rain gauges used in this study tip after every 0.01-inch of rain. Rain gauges at each test plot were inspected and cleaned prior to each forecasted “go” event.

A.3 WATER SAMPLE COLLECTION METHODS

Storm water samples collected during this study were collected using flow-weighted composite and grab sampling techniques. The sample collection methods are described in the following sections.

A.3.1 Flow-Weighted Composite Samples

Flow-weighted or flow-proportioned composite storm water samples were collected using automated sampling equipment installed near the discharge point from the v-ditch below each test plot. A sample aliquot of equal size was collected every time the pre-selected flow volume passed through the palmer-bowlus flume. Flow proportional sampling requires estimates of the following parameters:

- Storm event quantity of precipitation
- Expected runoff volume
- Expected storm duration
- Minimum required composite sample volume
- Minimum acceptable number of sampling aliquots, and
- Sample aliquot size.

To determine the sampler flow-proportional setting for the automated samples, a flow volume to sample volume calculation was conducted for each sampling location using the following equation:

$$V_r \text{ (acre – feet)} = \text{QPF (inches)} * 1\text{(ft)}/12 \text{ (inches)} * \text{A (acres)} * \text{C}$$
$$V_r \text{ (cf)} = V_r \text{ (acre-feet)} * 43{,}560 \text{ (cf)}/1\text{(acre – foot)}$$
$$V_s = V_r \text{ (cf)/CSA}$$

Where V_s = volume to sample ratio
QPF = storm event quantity of precipitation forecasted, inches
A = area of drainage basin, acres
C = runoff coefficient
V_r = total runoff volume for forecast storm (calculated)
CSA = number of composite aliquots required for complete composite
V_s = flow volume per sample

The automated sampling stations were checked periodically during each monitored storm event to make sure that the automated sampling equipment functioned properly. If the composite sample bottles filled more rapidly than expected, the sampling personnel replaced the bottles. If the composite sample collection period exceeded 24 hours, sample bottles were replaced at or prior to the end of each 24-hour period to ensure holding times for the chemical analyses were met.

Where multi-bottle compositing or composite sample splitting were required to prepare the sample for laboratory analysis, the compositing or splitting was conducted by the laboratory in general accordance with the procedures outlined in Section 7.8 of the SAP.

A.3.2 Grab Samples

Grab samples were required for parameters that transform rapidly or adhere to the automated sampling equipment. An attempt was made to collect grab water samples during each storm event. In general, the samples were collected as soon as practical after the flow rate stabilized during the storm event. However, due to the intensity and brevity of certain storms, grab samples were not collected during each storm event.

Grab samples were collected downstream of the automated sampler intake at each sampling location by inserting the sample container directly in the storm water discharge. The sample container was placed in the discharge stream with the opening facing upstream. Each sample bottle was filled to just below the neck of the container.

At Site 55S Orange County, storm water grab samples were collected and submitted to the laboratory for analysis of total petroleum hydrocarbons and ammonia. Grab samples collected from 73S Orange County were submitted to the laboratory for analysis of ammonia only. For the laboratory analyses performed, the grab samples did not require chemical preservation.

A.4 SAMPLE COLLECTION, HANDLING, AND PRESERVATION

Before each storm water monitoring event, sample bottles were prepared and pre-cleaned by the analytical laboratory using procedures described in the *Caltrans Guidance Manual: Storm Water Monitoring Protocol, Second Edition, July 2000* and as summarized in the SAP. Where required, the preservatives were added to the empty sample containers by the laboratory. Quality assurance trip blank samples were prepared by the laboratory and were submitted with each shipment of samples by the sampling personnel. The empty and pre-cleaned sample bottles were placed in ice chests and submitted to the field sampling personnel.

The sample identification information provided on each sample label included the project name, station name, event number, date and time of sample collection, sample ID number, sample type (grab or composite), sample bottle number (ie. bottle _ of _ for multi-bottle samples), preservative, required analysis, and the sampling personnels' initials. To the extent practical, the sampling personnel pre-labeled the sample bottles before each storm water monitoring event and completed the event-specific information such as the date and time of sample collection, the sample number, and the sampling personnels' initials when the samples were collected. In accordance with the SAP, each storm water sample collected received a unique alpha-numeric code (sample I.D.) for tracking. The following provides an example of the sample ID for a storm water sample collected during the first sampling event at a site.

- SITE# = Site ID Number (assigned by Larry Walker and Associates)
- 32800 = Julian day and year, or year, month, day, and military time (YYMMDDTTTT)
- 00# = The number of the sampling event
- #01 = QA/QC identification number

Field Sample	Field Duplicate Sample	Field Blanks
	Add 500	Add 600
SITE#-32800-001	**SITE#-32800-501**	**SITE#-32800-601**

Matrix spike/matrix spike duplicate (MS/MSD) samples were clearly noted on the Chain-of-Custody Form. No special sample identification number was required. During each storm event, field data was recorded on a During Storm Field Data Log Sheet and generally included: meteorological characteristics (duration and intensity of storm event), flow and field measurements (pH, conductivity, temperature, and time of measurement) for storm water samples collected at each location, sampling equipment condition and repair needs, and general observations related to water quality appearance and general site conditions. Qualitative observations regarding the erosion control characteristics of each product were also made.

The sample bottles, volume, and preservatives were appropriate for the requested laboratory analyses. The storm water samples were kept on ice or refrigerated to about 4 degrees Celsius from the time the sample was collected until delivery to the laboratory. The samples were usually delivered to the laboratory under chain-of-custody procedures utilizing the laboratory courier service. When the courier service could not be arranged to get the samples to the laboratory for analysis within the allotted holding times, field sampling personnel delivered the samples directly to the laboratory. Following each sampling event, the chain-of-custody was reviewed by the project manager to verify that the sample designations and requested analyses were correct.

APPENDIX B

STORM WATER SAMPLE ANALYSIS AND QUALITY ASSURANCE/QUALITY CONTROL

APPENDIX B

STORM WATER SAMPLE ANALYSIS AND QUALITY ASSURANCE/QUALITY CONTROL

This section summarizes the laboratory analyses and the field and laboratory quality assurance/quality control (QA/QC) procedures for collection of storm water samples during the erosion control field study. In general, the sample analyses and QA/QC procedures followed those described in the SAP for this project dated March 2001.

B.1 LABORATORY ANALYSES

The storm water samples collected during this study were submitted to Pat-Chem Laboratories, a California Department of Health Services-certified laboratory located in Moorpark, California. The storm water samples were analyzed for conventional analytical parameters (pH, temperature, conductivity, total dissolved solids, etc.), nutrients (nitrogen and phosphorus), and selected metals (total and dissolved) in general accordance with the *Caltrans Guidance Manual: Storm Water Monitoring Protocol, Second Edition, July 2000*. Several constituents were added to Caltrans' standard suite of analytes for each study site. These constituents were added based on a review of the chemical make-up of each test product at the study site. Material Safety Data Sheets and product specification sheets were reviewed to determine analytes that could potentially leach out of the products.

B.2 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

Field and laboratory QA/QC procedures were maintained during the storm water monitoring events conducted for this study. A detailed description of the QA/QC procedures and protocols to be conducted was provided in the SAP dated March 2001. The following subsections provide a summary of the field and laboratory QA/QC samples and procedures maintained during the storm water monitoring program.

B.2.1 Field QA/QC Samples

Field QC samples were collected during this study to evaluate potential contamination and sampling error introduced into a sample prior to its submittal to the analytical laboratory. Field QC samples included: blank samples (equipment, field, and trip), field duplicates, and matrix spike/matrix duplicate (MS/MSD) samples.

Equipment blanks were collected and used to assess cleaning procedures for non-dedicated field equipment. In summary, one equipment blank was collected from a new automated sampler, where a laboratory-grade contaminant-free water drawn through the automated sampler and collected in the appropriate sample containers.

Field blanks are used to determine if contamination was introduced during field sampling activities by ambient air conditions. The field blank samples are collected by pouring contaminant-free water directly into the appropriate sample containers in the field and preparing them for laboratory analysis.

Trip blanks were used to determine whether sample contamination was introduced during the transportation and shipment of the sample to the laboratory. Trip blank samples are prepared by the laboratory using a contaminant-free water. The trip blank samples were transported with the empty sample bottles to the field sampling personnel, were kept with the samples during the sampling event, and were submitted to the laboratory with the samples following collection of the field water samples.

Field duplicates are used to assess variability attributable to collection, handling, shipment, storage, and/or laboratory handling and analysis. In general, field duplicate samples were collected immediately following the collection of the original sample using the same procedures used to collect the original sample.

The MS/MSD samples are used by the laboratory to evaluate the precision and accuracy of the laboratory method and to evaluate any matrix interference that may occur during sample analysis. In summary, MS/MSD samples were collected by the field sampling personnel using similar procedures for the collection of field duplicate samples; however, the required sample volumes were three times the normal sample volumes. The samples were clearly identified to the laboratory as being MS/MSD samples. Once in the laboratory, the samples are “spiked” with a known amount of analyte(s) and analyzed to determine the percent recovery of each spike added to the sample.

The field QC samples were prepared and submitted to the laboratory in accordance with the sample handling and transportation procedures used for the storm monitoring samples collected during each storm event. With the exception of the MS/MSD samples, the samples were labeled with a unique identifier as described in Section B.4 of Appendix B and were not identified to the laboratory as being QC samples. The field QC sample collection was conducted in general accordance with *Caltrans Guidance Manual: Storm Water Monitoring Protocol, Second Edition, July 2000*.

B.2.2 Laboratory QA/QC Samples

Laboratory QC analyses were conducted to provide data needed to assess potential laboratory contamination, and analytical precision and accuracy. Laboratory QC samples included: blank samples (method and bottle), laboratory duplicates, and matrix spike/matrix spike duplicates (MS/MSD), and laboratory control samples (LCS).

Method blanks were prepared and analyzed by the laboratory to assess the potential level of contamination associated with the laboratory reagents and equipment. Bottle blanks were prepared and analyzed by the laboratory to assess the sample bottle cleaning procedures prior to transport of the sample bottles to the field for sample collection. Blanks consisted of a laboratory prepared sample of known chemical composition that is analyzed using the same analytical procedures as the field monitoring samples submitted for laboratory analysis. The blank results were assessed relative to the reporting limits for the analytical method and should reveal results that are less than the method detection limits to be acceptable.

Laboratory duplicate samples were generated by the laboratory by splitting a given sample and analyzing the two (split) samples independently. The duplicate sample results are evaluated by calculating the Relative Percent Difference (RPD) of analyte concentrations reported in the two sample sets and is used to evaluate the reproducibility or precision of the sampling results.

The preparation and analysis of MS/MSD samples was discussed in Section C.2.1. In addition, LCS samples were prepared and analyzed by the laboratory to assess the matrix effects on spike recoveries. The LCS samples were prepared by spiking a contaminant-free water with known amounts of analyte(s) and analyzing the samples to evaluate recovery of the spiking compounds in an interference-free matrix. When compared to the LCS samples, high or low recoveries of analytes in the MS/MSD samples may be caused by interference in the matrix of the field water sample.

As previously discussed, the laboratory QC samples were prepared and analyzed by the laboratory. In general accordance with the SAP, corrective measures were implemented if laboratory QA/QC results indicated unacceptable RPD ranges or problems with sample blanks or spiked samples.

The laboratory QC sample preparation and analysis were conducted in general accordance with *Caltrans Guidance Manual: Storm Water Monitoring Protocol, Second Edition, July 2000*.

B.3 DATA MANAGEMENT AND VALIDATION

The Task Order Manager was responsible for the data collection, tracking, management, validation, and reporting activities on this project. Prior to each storm event, the Task Order Manager coordinated with the field sampling personnel to ensure the collection of storm water and QA/QC samples for that monitoring event. Following submittal of the storm water samples to the laboratory, the Task Order Manager reviewed the chain-of-custody documentation for completeness.

The data packages for this project were provided in both hard copy and electronic formats. Upon receipt from the laboratory, the hard copy of the analytical data was reviewed to determine if formatting and general content met the project objectives. The data was validated using a two step process. First, Caltrans Automated Data Validation (ADV) software was used to provide a preliminary screening of the data for completeness, typographical errors, and suspect values. After this initial screening, manual QA/QC assessment of the data was conducted and included review of sample holding times, field and laboratory equipment and blank results, and the MS/MSD and LCS recovery data.

After review, a relational database was used to input and manage the electronic field and laboratory data collected during a storm monitoring event. Laboratory data included the analytical sample results and QA/QC data. Field data included rainfall, sampling, and discharge data recorded by the automated sampling equipment datalogger. Use of the relational database allowed graphical evaluation of the data for each event and comparison of data collected between different storm monitoring events.

B.4 DATA REPORTING

Three types of reports were prepared to transmit data collected during this study and included:

- monthly status reports;
- post-storm technical memorandums; and

- a final report for the erosion control study.

Monthly reports were submitted to the Caltrans Project Coordinator during the course of this study. The monthly reports included a summary of activities and accomplishments for the previous month, and the work activities to be project to be completed during the following month.

Following each of the five storms monitored during this study, a post-storm technical memorandum was prepared and submitted to Caltrans as a deliverable for each monitoring event. The technical memorandums were formatted similar to the format used for the Caltrans NPDES monitoring and include a description of the storm event, tabular summaries of the field and laboratory data collected, and a narrative summary of the performance of the field test plots during each sampling event.

The final report for the erosion control study is presented herein. The data from each storm event is summarized and evaluated to assess the performance of erosion control products used during this study. and includes the summarized data collected during each sampling event.